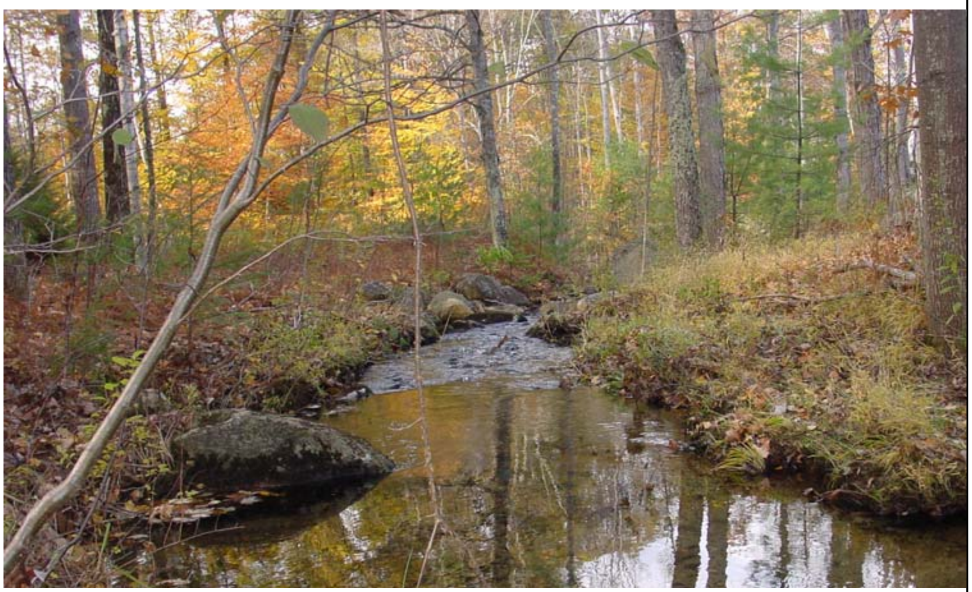
Quality Assurance
Project Plan

Mendums Pond Watershed Assessment



Prepared for:

NHDES

Prepared by:

UNH CFB

and

UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

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Quality Assurance Project Plan
Mendums Pond Watershed Assessment

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Date: September 21, 2006

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2.2 Document Control Format

The document control format is shown in the upper right hand corner of each page of this document.

2.3 Document Control Numbering System

A document control numbering system for all copies of this QAPP was not used because this project is of a small scale. The people who will receive copies of the QAPP are listed in Table 2 in Section 3.0.

2.4 EPA-NE QAPP Worksheet #2

All of the required elements of a project based QAPP have been covered in this document. The worksheet that follows on the next page has been annotated to indicate any deviations from the standard outline such as where sections have been combined due to the limited scope of field analysis and the resulting section number changes. It also indicates where a short narrative statement or bulleted list has taken the place of a formal table due to the limited scope of this project.

Table 1 EPA NE QAPP Worksheet #2

Required EPA QA/R-5 QAPP Elements	Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)	EPA-NE QAPP Worksheet #	Required Information (Table # in this QAPP) Note: strikethrough indicates information listed, but not as a table
Project Management and Objectives			
A1	1.0 Title and Approval Page	1	-Title and Approval Page
A2	2.0 Table of Contents and Document Format 2.1 Table of Contents 2.2 Document Control Format 2.3 Document Control Numbering System 2.4 EPA-NE QAPP Worksheet #2	2	-Table of Contents -EPA -NE QAPP Worksheet (1)
A3	3.0 Distribution List Project Personnel Sign-off Sheet	3 4	-Distribution List (2) -Project Personnel Sign-off Sheet
A4, A8	4.0 Project Organization 4.1 (Fig 1) Project Organizational Chart 4.2 (4.1) Communication Pathways 4.2.1 (4.2) Modifications to Approved QAPP 4.3 Personnel Responsibilities and Qualifications 4.4 Special Training Requirements/ Certification	5a 5b 6 7	-Organizational Chart -Communication Pathways -Personnel Responsibilities and Qualifications Table (3) -Special Personnel Training Requirements Table (4)
A5	5.0 Project Planning/Project Definition 5.1 Project Planning Meetings 5.2 Problem Definition/Site History and Background	8a 8b	-Project Scoping Meeting -Attendance Sheet with Agenda and other Project Planning Meeting Documentation -Problem Definition/Site History and Background -EPA -NE DQO Summary Form -Site Maps (historical and present; (Appendix G)
A6	6.0 Project Description and Schedule 6.1 Project Overview 6.2 Project Schedule 6.3 Summary of Analysis Tasks	9a 9b 9c 9d 10	-Project Description -Contaminants of Concern and Other Target Analytes Table (8,9) -Field and Quality Control Sample Summary Table (8,9) -Analytical Services Table (6A,6B) -System Designs -Project Schedule Timeline (5)
A7	7.0 Project Quality Objectives and Measurement Performance Criteria 7.1 Project Quality Objectives 7.2 Measurement Performance Criteria	11a 11b	-Project Quality Objectives/Decision Statements -Measurement Performance Criteria Table (7)
Measurement / Data Acquisition			
B1	8.0 Sampling Process Design 8.1 Sampling Design Rationale 8.2 Field Sampling Rationale 8.3 Rationale for Parameters Measured and Samples Taken	12a 12b	-Sampling Design and Rationale(10) -Sampling Locations, -Sampling and Analysis Method/SOP Requirements Table (11) -Sample Location Maps (Appdx G)

Required EPA QA/R-5 QAPP Elements	Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)	EPA-NE QAPP Worksheet #	Required Information (Table # in this QAPP) Note: strikethrough indicates information listed, but not as a table
B2, B6 B7, B8	9.0 Sampling Procedures and Requirements 9.1 Sampling Procedures 9.2 Sampling SOP Modifications 9.3 Cleaning and Decontamination of Equipment/Sample Containers 9.4 Field Equipment Calibration 9.5 Field Equipment Maintenance, Testing and Inspection Requirements 9.6 Inspection and Acceptance Requirements for Supplies/Sample Containers	13 12b 14 15	-Sampling SOPs -Project Sampling SOP Reference ~~Table~~ -Sampling Container, Volumes and Preservation Table (11) -Field Sampling Equipment Calibration ~~Table~~ -Cleaning and Decontamination SOPs -Field Equipment Maintenance, Testing and Inspection ~~Table~~
B3	10.0 Sample Handling, Tracking and Custody Requirements 10.1 Sample Collection Documentation 10.1.1 Field Notes 10.1.2 Field Documentation Management System 10.2 Sample Handling and Tracking System 10.3 Sample Custody	16	-Sample Handling, Tracking and Custody SOPs -Sample Handling Flow Diagram -Sample Container Label (Sample Tag) -Chain-of-Custody Form and Seal (Appendix E)
B4, B6 B7, B8	11.0 Field Analytical Method Requirements 11.1 Field Analytical Methods and SOPs 11.2 Field Analytical Method/SOP Modifications 11.3 Field Analytical Instrument Calibration 11.4 Field Analytical Instrument/ Equipment Maintenance, Testing and Inspection Requirements 11.5 Field Analytical Inspection and Acceptance Requirements for Supplies	17 18 19	-Field Analytical Methods / SOPs -Field Analytical Method / SOP Reference Table (12) -Field Analytical Instrument Calibration ~~Table~~ -Field Analytical Instrument / Equipment Maintenance, Testing and Inspection ~~Table~~
B4, B5 B7, B8	(all the sections below are integrated in the section 11 above) 12.0 Fixed Laboratory Analytical Method Requirement s 12.1 Fixed Laboratory Analytical Methods and SOPs 12.2 Fixed Laboratory Analytical Method/SOP Modifications 12.3 Fixed Laboratory Instrument Calibration 12.4 Fixed Laboratory Instrument/ Equipment Maintenance, Testing and Inspection Requirements 12.5 Fixed Laboratory Inspection and Acceptance Requirements for Supplies	20 21	-Fixed Laboratory Analytical Methods/SOPs -Fixed Laboratory Analytical Method/SOP Reference Table (12) -Fixed Laboratory Instrument Maintenance and Calibration ~~Table~~

Required EPA QA/R-5 QAPP Elements	Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)	EPA-NE QAPP Worksheet #	Required Information (Table # in this QAPP) Note: strikethrough indicates information listed, but not as a table
B5	13.0 (12.0) Quality Control Requirements 13.1 (12.1) Sampling Quality Control 13.2 (12.2) Analytical Quality Control 13.2.1 (12.2.1) Field Analytical QC 13.2.2 (12.2.2) Fixed Laboratory QC	 22a 22b 23a 23b 24a 24b	Sampling -Field Sampling QC Table (14) -Field Sampling QC Table cont. (14) Analytical -Field Analytical QC ~~Table~~ -Field Analytical QC ~~Table~~ cont. -Field Screening/Confirmatory Analysis Decision Tree -Fixed Laboratory Analytical QC Sample Table (15) -Fixed Laboratory Analytical QC Sample Table cont. (15)
B9	14.0 (13.0) Data Acquisition Requirements	25	-Non-Direct Measurements Criteria and Limitations Table (16)
A9, B10	15.0 (14.0) Documentation, Records and Data Management 15.1 (14.1) Project Documentation and Records 15.2 (14.2) Field Analysis Data Package Deliverables 15.3 (14.3) Fixed Laboratory Data Package Deliverables 15.4 (14.4) Data Reporting Formats 15.5 (14.5) Data Handling and Management 15.6 (14.6) Data Tracking and Control	26	-Project Documentation and Records Table (17) -Data Management SOPs
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C2	17.0 (16.0) QA Management Reports	28	-QA Management Reports ~~Table~~
	Data Validation and Usability		
D1	18.0 (17.0) Verification and Validation Requirements		-Validation Criteria Documents
D2	19.0 (18.0) Verification and Validation Procedures	29a 29b 29c	-Data Evaluation Process -Data Validation Summary ~~Table~~ -Data Validation Modifications
D3	20.0 (19.0) Data Usability / Reconciliation with Project Quality Objectives	30	-Data Usability Assessment

3.0 DISTRIBUTION LIST

Table 2 presents a list of people who will receive the approved Quality Assurance Project Plan (QAPP), the QAPP revisions, and any amendments. A project personnel sign-off sheet is not included in this draft. It will be generated upon finalization of the QAPP, and all people related to the project will indicate they have read the QAPP before completing any analysis work on this project.

Table 2. QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Contact Information: Telephone Numbers and email Addresses
Jeffrey Schloss	Project Co-Manager/ Field Team Manager	UNH Center for Freshwater Biology/ UNH Cooperative Extension	(603) 862-3848 jeff.schloss@unh.edu
Robert Craycraft	CFB Laboratory Quality Assurance Officer/ Laboratory Manager		(603) 862-3696 bob.craycraft@unh.edu
Steve Conklin	Project Manager and Lead Volunteer Monitor	Al Wood Drive Road Association	(603) 664-2563 sbconklin@aol.com
Jeff Merriam	UNH WQ Lab Quality Assurance Officer/ Laboratory Manager	UNH Dept. Natural Resources, WRRC	(603) 862-2341 jeff.merriam@unh.edu
Natalie Landry	NH DES Project Coordinator	NH DES Watershed Management Bureau	(603) 559-1507 nlandry@des.state.nh.us
Jillian McCarthy	NH DES Program Quality Assurance Coordinator	NH DES Watershed Management Bureau	(603) 271-8475 jjones@des.state.nh.us
Vincent Perelli	NH DES Quality Assurance Manager	NH DES Office of the Commissioner	(603) 271-8989 vperelli@des.state.nh.us
Warren Howard	EPA New England Project Manager	EPA New England	(617) 918-1587 howard.warren@epamail.epa.gov
Arthur Clark and/or Nora Conlon	EPA New England Quality Assurance Officers	EPA New England	(617) 918-8374 clark.arthur@epamail.epa.gov conlon.nora@epamail.epa.gov

(**BASED ON EPA-NE WORKSHEET #3**)

4.0 PROJECT ORGANIZATION

4.1. Project Responsibilities and Communication Pathways

Steve Conklin is the primary contact and project manager for the NH DES 319 Watershed Grant provided to the Al Wood Drive Road Association. He is the Chairman of the non-profit Al Wood Drive Road Association in Barrington, NH. The UNH Center for Freshwater Biology (CFB) was the approved and accepted bidder for the work plan elements contained under the grant.

Jeff Schloss is the UNH CFB Project Co-Manager for this investigation and is responsible for coordinating specific details of the project and ensuring that the work completed by the UNH CFB meets the scope and objectives of the project. Professor Schloss will coordinate all aspects of the project including the sampling surveys, data analysis, report preparation and budget oversight. Professor Schloss will be working closely with all interested parties to formulate an effective sampling plan and solicit feedback regarding sampling efforts. The Project Manager will be responsible for resolving any logistical problems, stop/go decisions for sampling, and communicating the results to the field staff. He will also notify the respective labs as when to be prepared to receive samples.

Robert Craycraft is the UNH CFB Quality Assurance (QA) Officer and Laboratory Manager. His primary responsibility will be to ensure that data collected throughout this investigation meet the quality objectives set forth in this QAPP. During the study he will be responsible for conducting analyses according to the procedures in this QA Project Plan, identifying any non-conformities or analytical problems, and reporting any problems to the Project Manager. Working with the Project Manager the Laboratory Manager will be responsible for resolving any analytical problems and communicating the results to the laboratory staff. At the end of this study the QA Officer will check, analyze and compile all QA/QC records and documentation. The QA Officer will be responsible for a memorandum to the Project Manager summarizing any deviations from the procedures in the QA Project Plan, the results of the QA/QC tests, and whether the reported data meets the data quality objectives of the project. The CFB Quality Assurance Officer, in conjunction with the CFB Project Manager, will also be responsible for training the CFB staff the applicable sample collection and water quality monitoring techniques required as outlined in this proposal.

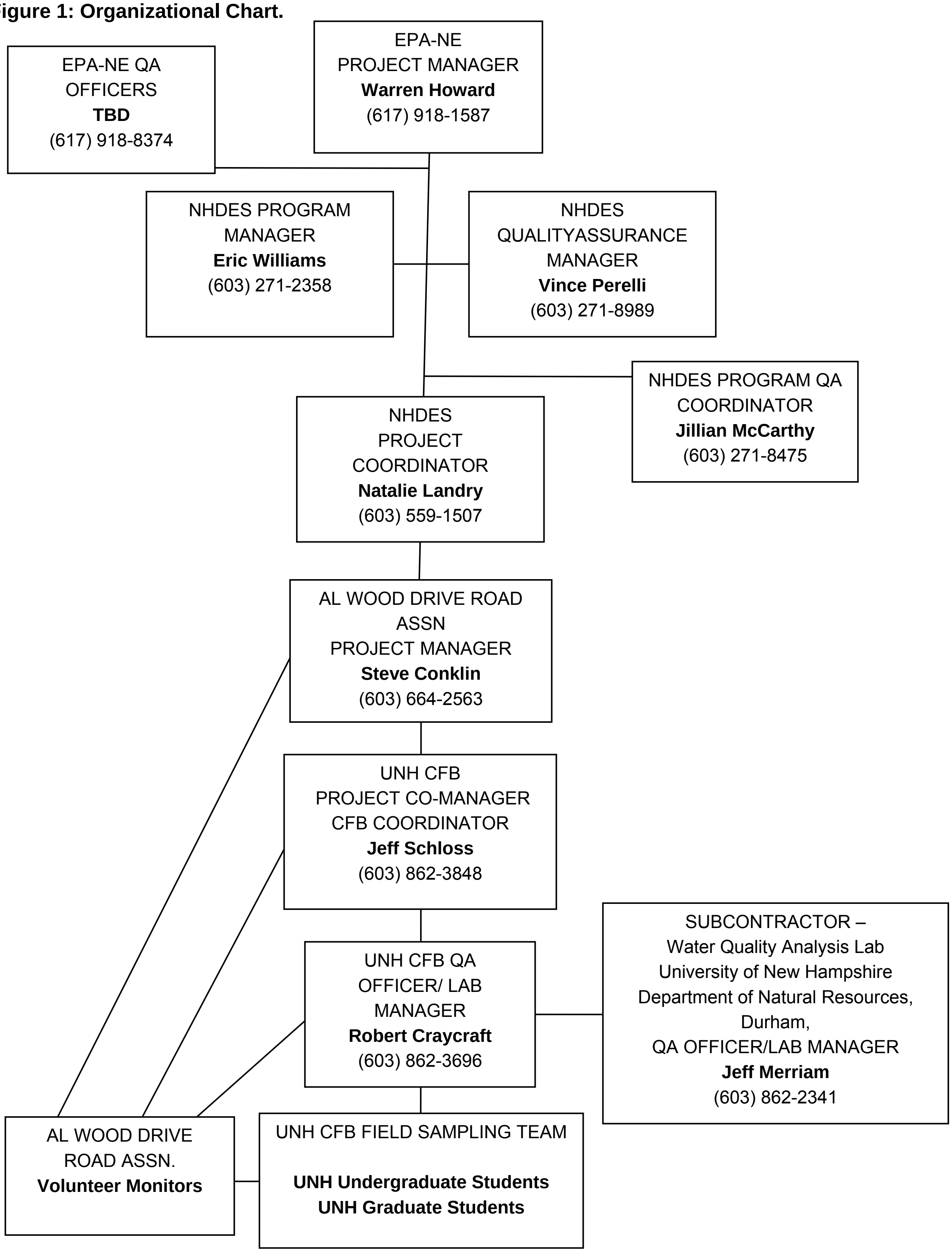
Field collections, field measurements and laboratory analysis as described in the work plan will be performed by the UNH CFB. Any nitrogen species and/or anion and cation samples (outside the current scope of the work plan unless additional funding is secured) with the exception of total nitrogen, will be subcontracted through the Water Quality Analysis Lab of the University of New Hampshire Natural Resources Department under the direction of Jeff Merriam who is the Quality Assurance Officer and the Laboratory Manager.

Funding for this project is made available through a New Hampshire Department of Environmental Services (NHDES) watershed assistance grant. Warren Howard is the EPA New England project officer for the Mendums Pond Watershed Assessment Project (MPWAP). Natalie Landry, the coastal watershed supervisor, is the project coordinator for the NHDES and is primarily responsible for working with the UNH Center for Freshwater Biology (UNH CFB) to ensure that the project scope is met. Jillian Jones and Vincent Perelli of the NHDES and an EPA New England Quality Assurance unit representative will review and approve the Quality Assurance Project Plan (QAPP) prior to project commencement.

The principal users of the data from this project will be the NHDES and the towns of Barrington and Nottingham, New Hampshire. The Project Manager will submit project updates as well as a final report to the NHDES Project Coordinator at the end of the project with all the data and the QA Officer's summary report. Project results may also be of interest to co-occurring projects not covered by this QAPP including the study of water quality impacts due to water withdrawal and the environmental impacts of urbanization.

Figure 1 is an organizational chart outlining the parties involved in this investigation and the communication pathways.

Figure 1: Organizational Chart.



4.2. Modification to Approved QAPP

The QAPP will be reviewed annually. If the sampling design, sample collection procedures, or data assessment and reporting change significantly, the UNH Project Coordinator will consult with the NH DES Project and QA Coordinators to submit modifications to EPA New England for approval.

4.3. Personnel Qualifications and Experience

Table 3 displays the personnel credentials of the Mendums Watershed Project Team. Responsibilities have been discussed in more detail above.

Table 3- Personnel Qualifications and Experience

Name and Affiliation	Responsibilities	Education and Qualifications
Steve Conklin Al Wood Drive Road Association Mendums Pond	Project Manager / Lead Volunteer Monitor	BS Mechanical Engineering Registered Professional Engineer (retired) US Navy Nuclear Engineer (retired)
Jeffrey Schloss UNH Center for Freshwater Biology, Cooperative Extension Department of Zoology	Project Co-Manager / UNH CFB Project Coordinator	BS Marine Zoology; BA Economics MS Marine and Aquatic Biology PhD candidate; Extension Professor; Water Resources Specialist
Robert Craycraft UNH Center for Freshwater Biology Cooperative Extension	CFB Laboratory Manager/ QA Officer	BS Biology; Educational Program Coordinator NH Lakes Lay Monitoring Program
Jeffrey Merriam UNH Water Quality Analysis Laboratory Water Resources Research Center	Laboratory Manager/ QA Officer	BS Water Resource Management; MS Water Resource Management; Associate Director NH Water Resource Research Center
CFB Student Technicians	Lab and Field Support	Trained by Project Manager and Laboratory Manager
Mendums Pond Volunteers	Collect field samples	Trained by Project Manager and QA Officer

(Based on EPA-NE QAPP worksheet #6)

4.4. Training Requirements/Certification

Table 4 displays the project activities that require some level of training and the location where the training records will be compiled.

Table 4 Special Personnel Training Requirements Table

Project function	Description of Training	Training Provided by	Training Provided to	Location of Training Records
Stream Water Sampling	Water sample collection procedures / Gage reading	Jeff Schloss & Robert Craycraft	Mendums Pond Volunteers	CFB Laboratory
Lake Data Collection	Use of Profiling Instrumentation. Field data collection protocols	Jeff Schloss & Robert Craycraft	CFB Field Team Members	CFB Laboratory
Stream Data Collection	Measuring Streamflow	Jeff Schloss & Robert Craycraft	CFB Field Team Members	CFB Laboratory

Based on EPA NE QAPP Worksheet #7

Volunteers will initially be trained during a group training session where they will be certified in water sample collection, staff gauge reading and instructed on how to fill out the data sheet. A yearly refresher/recertification will occur as a workshop or one-on-one depending on volunteer availability. See Section 6.1 II for additional information.

5.0 PROBLEM DEFINITION / BACKGROUND

This section documents the project planning, identifies the environmental problem, defines the environmental questions that need to be answered and provides background information.

5.1. Project Planning Meetings

Due to concerns regarding increasing development rates in the Mendums Pond watershed and proposed groundwater withdrawals, decision-makers and concerned citizens from Barrington and Nottingham requested assistance. In October of 2004, prior to submission of the grant proposal, a series of meetings were undertaken to discuss the possible tasks to include for application to the NHDES Watershed Grant Program. The following persons attended the various meetings and provided guidance and discussion in shaping what was to become the grant work plan:

- Jeff Schloss, UNH Extension Professor and Water Resource Specialist
- Robert Craycraft, UNH Educational Program Coordinator
- John Sasner, UNH Professor emeritus and Mendums Pond property owner
- Jody Connor, State Limnologist, NH Department of Environmental Services
- Jim Hadley, Nottingham Planning Board
- Steve Conklin, Mendums Pond property owner
- Carol Reilly, Barrington Town Administrator
- Natalie Landry, Coastal Watershed Supervisor, NH Department of Environmental Services

As a result of these meetings a watershed assessment project was designed to re-quantify nutrient loading sources and impact on Mendums Pond water quality since the late eighties. Included in the project is the development of a proactive planning tool for Mendums Pond and its watershed by drafting a phosphorus-based TMDL from the 1992 Clean Lakes Program Diagnostic Report, NHDES-WSPCD 92-4. This project has been underwritten by a NHDES 2005 Watershed Assistance Grant.

5.2. Background

The Mendums Pond watershed is located in the towns of Barrington and Nottingham. With increased development pressures facing local decision-makers in the two towns there is an increased need for scientifically-based information on the impacts of development in small watersheds. In 1992, the NHDES completed a diagnostic feasibility study (DFS) of Mendums Pond (NHDES-WSPCD 92-4). The intent of the DFS was to provide a baseline data set that could be compared to future watershed studies after significant watershed development to determine the impacts to water quality. The 1992 DFS identified a number of water quality issues and their causes, but lacked an implementation plan. As a result, many of the issues still exist today. The Mendums Pond Watershed Assessment Project will build on the 1992 DFS by focusing on the DFS's stated goal, "…to quantify the various avenues of phosphorus inputs to Mendums Pond…" and, "provide a basis for lake protection". This project will develop a proactive, protective scheme for Mendums Pond and its watershed through a phosphorus-based Total Maximum Daily Load (TMDL) study. The TMDL (to be detailed in a separate, abbreviated QAPP to follow) will be approved by an existing working group made up of community representatives, UNH faculty, NHDES and EPA New England. Additionally, an 18-month assessment of the pond by the UNH Center for Freshwater Biology (CFB) will update the data and analysis of the 1992 DFS study, as there has been significant growth in some of the sub-watersheds of Mendums Pond. This data will be available for future projects to amend the TMDL, as appropriate. The results from this project will also be useful to other Great Bay watersheds and coastal communities pending the ability to secure funding for measuring nitrogen and other chemical species to compliment the phosphorus measurements funded by this project.

Specifically, by allowing for both a current assessment of watershed nutrient loading as well as affording a comparison to the previous diagnostic study in the context of increased watershed development, this project will address the need to provide the towns with analysis and predictive tools to allow them to better manage growth in the Mendums watershed and adjoining lands. The primary pollutant of concern is phosphorus (the lake stressor variable) in the context of how it will impact lake productivity as measured by chlorophyll concentration (lake reaction variable). If funded through supplemental funding sources, nitrogen will be the secondary pollutant of concern. It is also hoped that the information supplied by this project will assist in creating a watershed management plan.

6.0 PROJECT / TASK DESCRIPTION AND SCHEDULE

6.1. Task Description

The Mendums Pond Watershed Assessment is designed to complete a series of objectives that will provide a better understanding of the impacts of development and population growth on the Mendums Pond watershed, the effects of major groundwater withdrawal, and the impact of land use change on the Mendums Pond water quality with particular emphasis on the rate of eutrophication. The Mendums Pond Watershed Assessment Project Grant includes a total of six tasks that will bring the project to completion:

- Prepare a Quality Assurance Project Plan (task I)
- Train Project Staff (task II)
- Perform an 18-month Mendums Pond water/nutrient budget (task III)
- Perform a groundwater seepage study (task IV)
- Author a phosphorus-based Total Maximum Daily Load Model (task V)
- Submit interim reports, prepare a Final Report, and meet with NHDES (task VI)
- Collect supplemental chemical and physical data that can augment the results of this study through future data analyses (task VII). Note: task VII is included in this QAPP to ensure that, should additional federal state or local funding be secured for supplemental water quality analysis (i.e.: nitrogen species), they shall be collected and analyzed in accordance with both NHDES and EPA QAPP approval. While beyond the current scope of this project, the collection of supplemental parameters should take place as they could provide additional

insight into the sources of pollutants that are entering the pond and also what impacts the outflow of Mendums Pond would have on the Great Bay Coastal Watershed

I. Prepare Quality Assurance Project Plan

A QA Project Plan for the Mendums Pond water/nutrient budget will be produced by UNH and approved by the NHDES and EPA New England before any field sampling on this project begins. This QAPP uses a combination of elements from previously accepted QAPPs written by UNH and approved by NHDES and EPA New England, guidance documents from the US EPA and EPA New England web sites and example QAPPs provided by NHDES. The water/nutrient budget field methodology is based on commonly employed field sampling methods previously used by NHDES in their Diagnostic Study of the watershed, while the laboratory analytical procedures are based on well accepted methods outlined in standard method manuals (APHA 1998, USEPA 1999) or are based upon methods that have previously been approved in an EPA New England accepted QAPP for similar water and nutrient budget studies conducted by the NHDES, the UNH CFB or other NH investigators.

II. Train Project Staff

The Project Manager will organize and implement a training session for field staff and volunteer monitors. The training session will cover SOPs for field instruments and field data sheets. The training will be based on the QA Project Plan document. Field staff and lab staff will sign an attendance sheet for the training. The training will be completed before field sampling begins. Refresher training (re-training) will be offered at the start of each sampling year.

III. Mendums Pond Water/Nutrient Budget

Rationale: The primary approach for the Mendums Pond Watershed Assessment Project (MPWAP) is to follow up on the comprehensive 1987-1990 Mendums Pond diagnostic/feasibility study, NHDES-WSPCD 92-4, which set a baseline for investigating water quality change with progressing watershed development. The proposed water/nutrient budget update will provide additional insight into the impacts of increased residential growth pressures that are occurring within the Mendums Pond watershed and that have altered the landscape since the initial Mendums Pond diagnostic/feasibility study was undertaken. The results of this study will provide better natural resource management strategies that can be incorporated into the master plans, local regulations and into growth management strategies employed by the Towns of Barrington and Nottingham. It should also serve as the basis of a watershed management plan. Monitoring of the previous study's sampling stations that represent perennial tributary inlets, and the Mendums Pond outlet (see table 9 and maps in Appendix F for all proposed monitoring sites), will allow for the comparison and change detection to take place. In addition, the added monitoring of ephemeral runoff areas during the spring melt and significant storm events will help account for ungauged watershed runoff. Sampling will be done by volunteers, UNH faculty, and students to track the total phosphorus, specific conductivity, temperature, turbidity, alkalinity and pH (the latter two are important as Mendums is listed as an acid impaired lake by the NHDES). The sampling design allows us to document the water volume, and the phosphorus loading that occurs in each of the Mendums Pond major subwatersheds and the outlet tributary. The study period will span approximately eighteen months, and an annual total phosphorus budget will be formulated over the twelve-month period where the most consistent data (at least two samplings per month and relatively normal weather conditions for that month) have been collected. The Mendums Pond water/nutrient budget will facilitate lake management at the watershed scale and will allow targeted educational and mitigative efforts at the subwatershed scales where the identified problems and concerns are most pressing. Outreach products from this project will involve the watershed community, concerned citizens, and local decision-makers.

Sampling Tasks: Physical and Chemical water quality samples and staff gauge readings will be collected by the volunteer monitors in the tributary inlets and in the Mendums Pond outlet on an approximate bi-weekly basis to document the short-term fluctuations in the discharge volumes and phosphorus loading. The proposed sample locations are discussed below, listed in Table 9 and indicated on the maps in Appendix F. Staff gauges will be positioned in the twelve tributary inlets and at the dam spillway and outlet stream and will be selected based on accessibility and stream bottom composition. Relatively flat-bottomed portions of the stream with unobstructed flow will be selected for staff gauge installation. All stream samples will be collected from near the gauged sites. Approximate bi-weekly water quality sampling will be undertaken by trained volunteers who will completely fill out a field sampling sheet, record the staff gauge height, and collect a total phosphorus sample. Monthly water quality measurements will be collected by the University of New Hampshire CFB field team to include temperature and specific conductivity samples, staff gauge height readings, stream morphology and stream velocity measurements. The CFB field team will complete a field data sheet at each sampling location, make recordings in a field log notebook and will collect total phosphorus, turbidity, alkalinity and pH samples for laboratory analysis. Storm event sampling will also be conducted by the CFB field team during a minimum of two major storm events, representing conditions when the phosphorus loading tends to be most severe in our coastal watersheds.

In-lake sampling will be conducted on a monthly basis between the months of April and November to span the months during which New Hampshire lakes typically become thermally stratified. The CFB field team will collect vertical water quality profiling data that will include depth, temperature, dissolved oxygen, specific conductivity, oxidation reduction potential, pH, turbidity, chlorophyll *a* (estimated via fluorescence) and underwater irradiance. Water quality chemistry data will also be collected as point samples in the epilimnion, metalimnion and hypolimnion that shall include total phosphorus, chlorophyll *a* (measured spectrophotometrically), true color, alkalinity and dissolved oxygen measured via the Winkler Method. An epilimnetic composite sample will be collected for the analysis of total phosphorus, alkalinity, chlorophyll a and true color at each sampling site while Secchi Disk transparency measurements, phytoplankton samples and zooplankton samples will also be collected at each in-lake sampling station. See Table 10 for the rationale of the selection for each of the parameters measured in this study.

A minimum of two high intensity storm events will be selected during which all twelve tributaries will be monitored by CFB field technicians to document the physical and chemical conditions during those events. The sampling will be conducted during an intense period of the storm event during which rainfall and runoff have exceeded base flow conditions.

Analysis Tasks: Stream Temperature and Specific Conductivity measurements will be measured in-situ throughout the monitoring period while stream water samples will be collected and analyzed in the laboratory for total phosphorus and turbidity. Discharge measurements will be calculated based on the stream channel dimensions and/or culvert dimensions, water depth and the concurrent stream flow measurements. Discharge calculations will be based on standard hydrological calculations (width * depth * velocity along a transect across the stream channel) and a rating curve shall be developed to calculate the discharge volumes for each sampling date. Laboratory analyses will be performed in the CFB laboratory and will include Total Phosphorus (TP) analysis, through persulfate digestion, Turbidity analysis using a portable Turbidimeter, total alkalinity through a colorimetric (fixed ph) end point, and pH by electrometric probe. In-lake sampling will include the collection of thermal profiles and the collection of point and composite water samples that will be analyzed for chlorophyll and true color through spectrophotometric detection, alkalinity, carbon dioxide and dissolved oxygen (QC of probe) by titration, temperature oxygen, pH, specific conductivity, Orp and chlorophyll fluorescence profiles by multiparameter electronic probes. In-lake biological sampling will also include the collection of phytoplankton and zooplankton samples.

IV. Groundwater Seepage Study

Rationale: In addition to surface runoff and internal nutrient cycling from the sediments, the nutrient loading occurring from groundwater, especially those that may be influenced by septic seepage are important to quantify.

The design of the groundwater seepage study follows that of the 1992 Mendums DFS. Sixteen seepage units (cut top sections of 45 gallon drum containers fitted with an outlet control and water collection bag) will be deployed at various locations and various shallow depths of the pond. Selected sites will follow those previously used by NHDES whenever possible to afford the best temporal comparison. As seepage meters can alter the naturally occurring oxidation conditions in the sediments they cover, an interstitial pore water sampler (IPWS) will be employed to sample the groundwater for nutrient analyses. As a check on the IPWS sampling, we will also occasionally sample water from shallow well systems around the lake shore on a seasonal basis (a minimum of 4 samples) as conditions allow.

Sampling Tasks: The UNH CFB field team will deploy the seepage meters and take seepage measurements during the ice-free season at least once per month. This sampling will include repeated monitoring during the same day to calculate daily variations as well as variation over a longer temporal scale. During the same sampling events, an IPWS will be used to collect a sediment pore water sample to represent groundwater nutrient concentrations. On occasion, the UNH field team will also secure water samples from shallow wells and the existing drilled sampling well system located on the Sasner lot that was originally installed during the 1992 Mendums DFS to monitor groundwater movement of septic leach field seepage.

Analysis Tasks: Laboratory analyses will be performed in the CFB laboratory and will include Total Phosphorus (TP) analysis, through persulfate digestion, pH and conductivity.

V. Total Maximum Daily Load Model

With guidance from EPA New England and NHDES, a Total Phosphorus TMDL for the Mendums Pond Watershed will be developed. We will rely on the current NHDES recommendation for nutrient criteria based on nutrient levels and chlorophyll (response variable) recently developed through the Water Quality Standards Advisory Committee, and initially use data provided from the previous NHDES watershed diagnostic. When possible, the CFB will perform any updating of data as the newer diagnostic progresses but the scope of work for the subcontract of the NHDES grant agreement specifically calls for the 1992 NH DES report data to be employed (an abbreviated QAPP will be submitted for this project component).

VI. Submit interim reports, prepare a Final Report, and meet with NHDES.

Semi-annual updates will be provided by e-mail to the NHDES Project Coordinator. The final work product will a final report written in accordance with the "319 Program Final Report Guidelines" and will include an Excel spreadsheet containing quality assured results of the analyses that were collected as part of the Mendums Pond water/nutrient budget and as part of the groundwater seepage study. Included with the data will be a metadata listing to allow the project data to be available for uploading to STORET and the NHDES Environmental Monitoring Database (EMD) or similar data warehouses administered by NHDES and or EPA. The QA/QC data will also be included and summarized in the respective reports. The following reports will be included / provided:

- A Total Maximum Daily Load Model summary report.
- A Mendums Pond water/nutrient budget summary report that includes the groundwater seepage study summary report.

A final project meeting among the UNH Project Manager, NHDES staff and local officials from the Towns of Barrington and Nottingham (that includes the Mendums Pond working group) will also take place to discuss project results at a time convenient for the watershed community.

VII. Collect Supplemental chemical and physical water quality data.

Supplemental water quality data, contingent upon the availability of financial resources, will be collected as part of the stream and lake sampling locations that are outlined in tasks III and IV: the Mendums Pond Water/Nutrient Budget and the groundwater seepage study. Supplemental stream samples for nitrogen forms would augment the total phosphorus, specific conductivity, tributary and discharge data that will be collected in task III while the supplemental anion and cation data would enhance the information gleaned from the groundwater seepage study. The supplemental water quality samples could include the collection of orthophosphorus, total nitrogen, total dissolved nitrogen, nitrate nitrogen, ammonium nitrogen, silica, calcium, magnesium, sodium, potassium, chloride, sulfate and total suspended solids. The supplemental water quality samples would be collected at some, or all of the designated stream and groundwater sampling locations at intervals deemed sufficient to provide additional insight into the condition of the Mendums Pond watershed and provide additional elucidation into potential pollution sources.

6.2. Project Schedule

Table 5 summarizes the tasks listed above and includes the projected schedule to complete them.

Table 5. Anticipated Project Schedule.

Task	Anticipated Dates of initiation and completion	Responsible Persons / Group	Products	Rationale
QAPP development	November 2005 – September 2006	UNH Project Manager	Draft QAPP	NH DES and EPA QAPP approval required for grant
QAPP approval	October 2006	NH DES and EPA QA Officers	QAPP	To help insure data collected will meet QA/QC standards
Install Staff Gauges in study streams	May 2006 – September 2006	UNH Project Manager and CFB Field staff	Deployed Staff Gauges	Staff gauges will be used to determine discharge in each of the study streams on a weekly basis.
Staff Training	May 2006 – ongoing as needed	UNH Project Manager and Lab Manager	NA	QA/QC, preferred field practices, safety
Total Maximum Daily Load Analysis	May 2006 – September 2007	UNH Project Manager	Draft TMDL Report	To develop a TMDL that can be used at the local planning level to identify and control phosphorus loading.
Stream Sampling [1]: **Year 1** **Year 2**	October 2006 – September 2007 October 2007 – March 2008	UNH CFB	Annual physical and chemical data summaries	Collect discharge data and accompanying physical and chemical measurements that will be used to quantify the water and phosphorous load that will culminate in the Mendums Pond water/nutrient budget.
Lake Sampling [1]: **Year 1** **Year 2**	October 2006 April 2007 – October 2007	UNH CFB	Annual physical, chemical and biological data summaries	Collect vertical profile data, Secchi Disk transparency data and point physical, chemical and biological samples.
Groundwater Seepage Study Yr1 and Yr2	October 2006 – September 2007 October 2007 – March 2008	UNH CFB	Data Summary	Collect seepage samples and ,measure seepage volumes from shallow water areas around the Mendums Pond shoreline to determine seepage nutrient and water components for the water nutrient budget
Final Reports to NH DES **TMDL Study (1990 data)** **Water/Nutrient Budget** **Groundwater Seepage**	Ongoing – December 2007 Ongoing – April 2008	UNH Project Manager	Reports	Produce summary reports for distribution among the working group members.
Meetings/ Outreach Events (not under scope of grant UNH will assist at no charge)	Ongoing, upon release of final report and when requested	Project Manager	Meetings/ Outreach Materials	A meeting will be held where potential and future steps aimed at reducing NPS pollution and protecting the surface water and groundwater resources would be discussed.

(Based on EPA- NE Worksheet #10.)

[1]- Refers to components of the Mendums Pond Water/Nutrient Budget.

6.3. Summary of Analysis Tasks

Tables 6A and 6B present a breakdown of who will be responsible for sample analysis and field work. Water Quality parameters that will be collected contingent upon the availability of a supplemental funding source, are denoted with an asterisk (*).

Table 6A. - Laboratory analytical services table

Analyte	Laboratory contact or instrument and person responsible
Matrix / Lab Analysis	
Stream Water: Total Phosphorous Total Nitrogen * Total Suspended Solids *	UNH Center for Freshwater Biology Analytical Lab (CFB) UNH Spaulding Hall G-18 Durham, NH 03824 Robert Craycraft, Lab Manager (603) 862-3696 bob.craycraft@unh.edu
PH Turbidity Alkalinity	Hanna Instruments model HI 9025 pH meter w/ Beckman Star® Series Low Ionic Strength combination pH probe (Part #511071) LaMotte 2020 Turbidimeter UNH CFB Titration Test Kit (.002N H_2SO_4)
Stream/Lake Water *: (filtered) Orthophosphorus* Total Dissolved Nitrogen* Nitrate-N* Ammonium – N* Silica as SiO_2 * Calcium* Magnesium* Sodium* Potassium* Chloride* Sulfate*	Water Quality Analysis Lab (WQA) University of New Hampshire Department of Natural Resources, James Hall Durham, NH 03824 Jeff Merriam QA Officer/Lab Manager (603) 862-2341 jeff.merriam@unh.edu
Lake Water:	
Total Alkalinity Chlorophyll a Dissolved "true" Color Free Carbon Dioxide Dissolved Oxygen	UNH CFB Titration Test Kit (.002N H_2SO_4 titrant) Spectrophotometric analysis via Std. Meth. 10200 H.2 Spectrophotometric analysis via Std. Meth. 2120B Titration via Std. Meth. 4500-CO2 C. Winkler Titration via Std. Meth. 4500-O C. to QA electrical DO probe

(Based on EPA-NE Worksheet #9d)

Notes: *- represents a parameter not currently within the scope of the grant project work plan but for which additional funding requests from various sources have been made.

Table 6B. – Field analytical services table

Analyte	Laboratory contact or instrument and person responsible
Matrix / Field Analysis	
Stream Water: Temperature and Conductivity Stream Velocity	YSI Model 30 Temperature/Conductivity Meter YSI SonTek Flowtracker Handheld ADV
Lake Water: Temperature, Dissolved Oxygen, Oxidation Reduction Potential, pH, Specific Conductivity, Turbidity and Chlorophyll *a*	YSI 6600 Sonde fitted with: • YSI Model 6562 Dissolved Oxygen Probe • YSI Model 6560 Conductivity/Temperature Probe • YSI Model 6565 Combination pH/ORP Probe • YSI Model 6136 Turbidity Probe • YSI Model 6025 Chlorophyll Probe
Underwater Irradiance	Li-Cor LI-1400 data logger, L193 submersible cell and L191deck cell
Zooplankton	Aquatic Research Instruments 64um mesh plankton net; Dissecting Microscopy at 80x magnification.
Phytoplankton	Aquatic Research Instruments Van Dorn, Inverted Microscopy at 400x magnification.
Secchi Disk	Wildco Company Limnological Secchi Disk Person responsible for training: CFB Project Manager (Schloss) Person responsible for equipment: CFB Lab Manager (Craycraft)

(Based on EPA-NE Worksheet #9d)

*

7.0 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

7.1. Project Data Quality Objectives (DQOs)

This project is designed to quantify the nutrient load and water load into Mendums Pond and to conduct a study of the groundwater seepage into Mendums Pond. Thus, the level of data quality must ensure that field collection and sample processing will allow the proper characterization of the phosphorus and water loading values. The proposed water sampling design described above will yield sufficient data for this purpose. Precision, accuracy/bias, quantitation limits and completeness of data are addressed in Section 7.2 below.

The CFB will analyze the accumulated results to make recommendations for follow-up research and potential control strategies that will mitigate existing and future pollutant sources.

7.2. Measurement Performance Criteria for Water Quality Measurements

An overview of the measurement performance criteria to be used in this study for water samples is listed in Table 7 and explained in more detail below it. The specific performance criteria goals and related information for each analyte/measurement are listed in Table 8.

Table 7. Measurement Performance Criteria Used for Water Quality Measurements

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance
Precision-Overall	RPD	Field Duplicates
Precision-Lab	RPD	Lab Duplicates
Accuracy / Bias	RPD % R (Yield) r^2	Certified Reference Materials Laboratory Fortified Matrix Spikes Standard Calibration Curve
Comparability	Measurements should follow standard methods that are repeatable	All project personnel will review QAPP and receive training / Signed record of such.
Sensitivity	MDL	Yearly (at minimum) Method Detectable Limit Calculation
Completeness	Number of samples meeting data quality objectives	Data Completeness Check
Contamination	≤ Laboratory Quantitation Limit	Field Blanks Lab Blanks

(Based on EPA NE Worksheet #11b)

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected at the same time and location. Precision will be assessed as the relative percent difference between duplicate measurements taken in the field, and the relative percent difference between duplicate samples created in the lab. Duplicate measurements will also be made for each field parameter measured.

The relative percent difference (RPD) will be calculated as follows:

$$RPD = \left(\frac{\left| x_1 - x_2 \right|}{\frac{x_1 + x_2}{2}} \right) \times 100$$

where the equation numerator is the absolute value of the difference between duplicates.

RPD will be calculated for each sampling visit. The desired field and lab precision data are reported in Tables 7 and 8. For the CFB in-lab nutrient analyses all samples are run as duplicates and any discrepancies for a sample above the stated precision requires a re-run of that sample (unless the average of the two samples is less than 10X the MDL). For the WQA laboratory duplicates (unless otherwise noted on Tables 6 and 7), a difference greater than 10% requires further investigation of the sample run. A difference greater than 15% is failure (unless the average of the two samples is less than 10X the MDL), and results in reanalysis of the entire sample run, unless there is a reasonable and supported explanation for the inconsistency. For all field duplicates, a difference less than 5% below the desired RPD will be considered suspect and differences greater than the RPD will be flagged as a potential error and run again. If the second run does not fall within the allowable range, the data will be flagged as unacceptable and the sampling and handling protocols will be investigated further.

Accuracy

Accuracy or percent error is the degree of agreement between the observed value (i.e., measured, estimated, or calculated) and an accepted reference or true value (i.e., the real value). Laboratory accuracy will be measured through spiked samples, prepared controlled samples, instrument blanks or certified reference materials as appropriate for individual methods. Frequency and selection of accuracy measurement depends on methods. To create a spike sample, a field collected sample will be divided into two portions (aliquots). A known amount of standard is added (spiked) to one of the aliquots. Both aliquots are then analyzed and the amount of the spiked material recovered is compared to the amount added using the following equation:

$$\%R = \frac{(Spiked\ sample - Original\ sample)}{(Spiked\ amount)}\ x\,100$$

Total phosphorus samples processed in the CFB lab that are paramount to the Mendums Pond water/nutrient budget will be assessed for accuracy at a frequency of 10% of all samples run or one per analytical batch, whichever is more frequent.

As pH is a logarithmic scale and buffered solutions are the certified reference solutions used for pH, that accuracy will be expressed as the difference between the measured value and the value expected from the certified reference standard in pH units. Certified reference samples are also used in most of the nutrient and ion analytical runs as individual standards or combined standards. When reporting accuracy in these cases (in addition or as an alternative to spiked samples) the following formula will be used for percent recovery (using a blank for the matrix):

$$\%R = \frac{(Result\ for\ Analyte\ in\ Certified\ Reference\ Material)}{(Verified\ Amount\ of\ Analyte\ in\ Certified\ Reference\ Material\ from\ Vendor)}\ x\,100$$

A third accuracy check involves the regression results of the certified reference standards commonly included in each analytical batch. In these cases, the r^2 value of the standard regression is to be reviewed.

Representativeness

Representativeness is a qualitative term that describes the extent to which a sampling design adequately reflects the environmental conditions of a site. The primary goal of the Mendums Pond water/nutrient budget is to quantify the phosphorus load into Mendums Pond. The collection of bi-weekly total phosphorus samples, as well as supplemental storm event samples as weather patterns dictate, will allow us to document the annual range of conditions and use these data to determine the annual phosphorus load into Mendums Pond.

Comparability and Sensitivity

Comparability is important since the data obtained will be used as an indication of what similarities and difference exist among the Mendums Pond tributary inlets and among the points of groundwater seepage into Mendums Pond. Thus, data collection and data analysis will be done in a similar way to the previous study. The sensitivity of the methods is important to be able to yield the results at the level necessary to perform this comparison.

Maintaining consistency with SOPs and using standardized sampling methods will achieve comparability among samples. Samples will be collected in a consistent way throughout the study and all samples will be processed within the specified holding times. In regard to sensitivity, tributary loadings and groundwater seepage have previously been studied in Mendums Pond as part of the 1992 Mendums Pond DFS. Comparability of data will be important to determine whether or not the results of this project fall within what has previously been documented as part of that DFS or if significant change has occurred in any subwatershed and, if so, can it be explained.

Completeness

The completeness of the database is a critical aspect of data quality and data usefulness. We expect, at the minimum, to collect almost bi-weekly sampling for each of the 14 historical tributary sampling sites over the 18 month study (504 tributary total phosphorus samples total plus QA samples), this assumes no logistical or unaccounted complications such as atypically dry conditions during which there is no water in the stream channels, culverts or dam outflow. We also plan to collect additional samples during the runoff season and major storm events at the minimum for three additional sites. A completeness of 80% of all samples planned or at least 2 samples per month per site when flow is evident is the minimum requirement established for the Mendums Pond water/nutrient budget component of this project. We also intend to follow the quality control and assurance procedures stated in this QAPP. An additional goal is to have obtained 100% of the planned QC samples; however, 90% completeness for QA samples will be considered acceptable.

Contamination

Field decontamination procedures (detailed in Section 9.3 below) and sample and lab methodology SOPs (appendices) are designed to limit sample to sample contamination and check for instrument drift. A check on those processes will involve the use of lab and field blanks that will be taken at the end of each field sampling session (after decontamination procedures are followed) and for each lab assay run. In the field, distilled, deionized (DDI) water will be "collected" as the actual samples were and processed as a field sample. In the lab, the proper blank matrix will be used.

Table 8. Data Quality Objectives for the Water Matrix Samples

Analyte (Sample Source)	SOP Method	Desired Precision	Desired Accuracy	Analytical / Achievable Method Detection Limit[1]	Analytical / Achievable Laboratory Quantitation Limit[2]	Typical Measurement Range
Laboratory Analysis						
Total Phosphorus (Stream / Lake / Seepage Water)	Appendix A3	RPD ≤ 20% (Field) RPD ≤ 10% (Lab)	90-110% RPD ≤ 10% $r^2 \geq 0.995$	0.8 µg/L	2.0 µg/L	0 – 500 µg/L P
Turbidity (Stream Water)	Appendix B	RPD ≤ 5% (Field) RPD ≤ 5% (Lab)	± 1.0 NTU	0.01 NTU	*NA*	0 – 50 NTU
pH (Stream Water)	Appendix B	RPD ≤ 0.2 std units (Field)	± 0.2 pH units	*NA*	0.1 pH units	2 –12 pH Units
Total Alkalinity (Lake Water)	Appendix B	RPD ≤ 15% (Field)	85-115%	0.2 mg/L	0.5 mg/L	0 – 20 mg/L $CaC0_3$
Carbon Dioxide (Lake Water)	Appendix A (titration)	RPD ≤ 15% (Field) RPD ≤ 10% (Lab)	85-115%	0.2 mg/L	0.5 mg/L	0 – 30 mg/l
Dissolved Oxygen (Lake Water)	Appendix A (titration)	RPD ≤ 10% (Field) RPD ≤ 5% (Lab)	85-115%	0.2 mg/L	0.5 mg/L	0 – 15 mg/l
Chlorophyll	Appendix A8	RPD ≤ 10% (lab)	+/- 15% of Turner Standard	*NA*	*NA*	0 – 50 µg/l

Analyte (Sample Source)	**SOP Method**	**Desired Precision**	**Desired Accuracy**	**Analytical / Achievable Method Detection Limit[1]**	**Analytical / Achievable Laboratory Quantitation Limit[2]**	**Typical Measurement Range**
Field Analysis (stream water)						
Temperature	Appendix B	+/- 0.2°C	+/- 0.2°C	NA	NA	0 - 30°C
Specific Conductivity	Appendix B	RPD ≤ 5%	+/- 5%	NA	NA	0 - 1000 µS/cm
Stream Velocity/Depth	Appendix B	RPD ≤ 10%	+/- 1%	NA	NA	0 – 50 CFS
Field Analysis (lake water by YSI 6600 Sonde)						
Depth	Appendix B	RPD ≤ 5%	+/- 0.12 m	0.01 m	NA	0-20 m
Temperature	Appendix B	RPD ≤ 5%	+/- 0.15°C	NA	NA	0 – 30°C
Dissolved Oxygen	Appendix B	RPD ≤ 5%	+/- 2% of reading	0.1 mg/L 0.1%	NA	0 – 15 mg/l
Conductivity	Appendix B	RPD ≤ 5%	+/- 5%	0.5µS / cm	NA	0 – 1000 µS/cm
pH	Appendix B	RPD ≤ 5%	+/- 0.2 units	NA	NA	0 – 12 pH Units
Oxidation Reduction Potential (ORP)	Appendix B	RPD ≤ 5%	+/- 20 mV	NA	NA	-100 – 400
Turbidity	Appendix B	RPD ≤ 5%	+/- 0.2%	NA	NA	0 – 50 NTU
Chlorophyll	Appendix B	RPD ≤ 15%	+/- 20%	NA	NA	0 – 50 µg/l
Underwater Irradiance	Appendix C	RPD ≤ 10%	R2 > .95 (with depth)	NA	NA	0 – 2500 µE/cm
Supplemental Analysis of tributary (stream) and seepage water (if funded)						
Dissolved Ortho-Phosphorus (stream water)	Appendix A2	RPD ≤ 20% (Field) RPD ≤ 10% (Lab)	85 – 115% RPD ≤ 10%	0.3 µg/L	1.5 µg/L	0 – 200 µg/L P
Total Nitrogen (stream/lake water)	Appendix A4	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115% RPD ≤ 15%	0.015 mg/L	0.05 mg/L	0 – 10 mg/L N
Total Dissolved Nitrogen (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115% RPD ≤ 15%	0.029 mg/L	0.10 mg/L	0 – 10 mg/L N
Nitrate Nitrogen (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.003 mg/L	0.05 mg/L	0 – 10 mg/L N
Ammonium Nitrogen (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	1.5 µg/L	3.0 µg/L	0 – 200 µg/L N
Silica as SiO_2 (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.3 mg/L	0 – 40 mg/L Si02
Sodium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0 – 15 mg/L Na

Analyte (Sample Source)	SOP Method	Desired Precision	Desired Accuracy	Analytical / Achievable Method Detection Limit1	Analytical / Achievable Laboratory Quantitation Limit2	Typical Measurement Range
Potassium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%%	NA	0.05 mg/L	0 – 7 mg/L K
Magnesium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0 – 7 mg/L Mg
Calcium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0 – 10 mg/L Ca
Chloride (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.02 mg/L	0.2 mg/L	0 – 15 mg/L Cl
Sulfate (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.04 mg/L	0.1 mg/L	0 – 8 mg/L SO4

(Based on EPA NE worksheet 9b and 9c)

1 Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

2 Quantitation limit for samples analyzed in the Water Quality Analysis Lab are based on user experience and previous analysis (not statistically calculated); those used by the CFB Analytical Lab are calculated as 2.5 to 10 times the MDL for analyses depending on the method and familiarity with routine method performance

8.0 EXPERIMENTAL DESIGN (SAMPLING PROCESS DESIGN)

8.1. Rationale for Design

As stated earlier, the purpose of our investigation is to re-quantify nutrient loading sources and the impact on the Mendums Pond water quality that have changed since the late eighties when water quality data were extensively collected within the Mendums Pond watershed and to quantify the amount of groundwater seepage that is closely tied to the Mendums Pond water/nutrient budget.

We plan to address the following specific goals:

a. Analyze the physical and chemical characteristics of the major tributary inlets into and out of Mendums Pond. Particular emphasis will be placed on the characterization of the stream channel morphology and the stream velocity and the analysis of total phosphorus, temperature, specific conductivity, pH and turbidity. Supplemental chemical parameters might be collected as time and financial resources permit that could include anion/cations and total suspended solids.
b. Quantify the groundwater seepage and groundwater phosphorus load into Mendums Pond
c. Conduct in-lake water quality testing at the two deep sampling basins to better understand the ponds' trophic state. In-lake profiling will be undertaken at each deep site and will include depth, temperature, dissolved oxygen, specific conductivity, oxidation reduction potential, pH, chlorophyll and turbidity measurements. Point and composite water quality samples will also be collected for zooplankton, phytoplankton, total phosphorus, chlorophyll a, true color, and alkalinity while supplemental anion/cation data might be collected as time and financial resources permit.
d. Produce a water/nutrient budget that will be packaged as a document that contains summary text, a complete data listing, graphical display of data and maps and images that depict the sampling locations.

This QAPP outlines our intended sampling strategy and analytical procedures to meet these goals.

8.2. Field Sampling Rationale

(See also rationale discussion in section 6.1 above) Sampling is planned for September 2006, following final EPA QAPP approval, through early December 2007 during which the Mendums Pond tributary inlets, and outlet, will be monitored on an approximate bi-weekly basis to obtain the data necessary to calculate the phosphorus and water load to Mendums Pond. Supplemental storm event sampling will also be undertaken to augment the weekly data and to provide additional insight into the variations in nutrient load that occur during base flow and peak flow periods. More frequent data might be collected during the spring runoff period and following heavy storm events (storms predicted at greater than 2.0"/day, and sampled approximately 1 to 2 hours after the start of the storm. to further refine the Mendums Pond water/nutrient budget but shall be undertaken at the discretion of the CFB Project Manager. Lake data collected during the months of April through September will provide additional insight into the lake's current state of eutrophication and may also provide important insight into the Ponds' response to nutrient loading that occurs over the course of this study.

Groundwater seepage will also be monitored between September 2006 and December 2007, following final EPA QAPP approval, as part of a separately contracted, but interrelated, study. Groundwater seepage meters will be deployed at select locations around Mendums Pond to help quantify the amount of groundwater flux, and affiliated nutrient loading, that occurs. The results of this study will also be utilized in the Mendums Pond water/nutrient budget to calculate groundwater inflow estimates and the groundwater phosphorus load.

8.2.1. Choice Of Study Streams

The study streams have been selected to include all appreciable sources of channelized surface water into, and out of Mendums Pond. The study streams include those streams that were sampled and are reported in the 1992 Mendums Pond Diagnostic/Feasibility study. Each of the stream gauging/monitoring locations will be selected close to the lake edge to assure all watershed inputs to the respective streams are accounted for. However, the CFB field team will also ensure that the stations are set far enough upstream from the lake edge to avoid the influence of lake effects and the effects of back-flushing into the stream. In addition we will evaluate three additional sites for inclusion during high runoff periods including a site near the Howe Brook locations, a site southeast of McDaniel Brook and a site located near the bridge brooks on the UNH property.

Table 9. Mendums Pond Study Streams.

Study Streams	Site ID	Location: Latitude Longitude	Sampling Site Description	Stream Sampled in DES Study	Rationale/ Comments
Wood Road Brook	Men01T	43° 10' 34.3272” 71° 4' 12.8136"	Located above Conklin driveway; receives drainage from new development (Gerrior Drive subdivision)	Yes	The Tributary sampling locations were selected to ensure all major sources of channelized flow entering and leaving Mendums Pond would be quantified in terms of discharge and phosphorus load. Discharge and phosphorus loading calculations in un-gauged subwatersheds, where distinctive tributaries do not exist, shall be modeled using the areal phosphorus loading values from the most similar gauged watershed(s) to avoid errors that can arise when un-gauged watersheds are “lumped” into gauged watersheds.
Storm Brook	Men16T	43° 10' 52.5000"” 71° 4' 25.6476"	At driveway culvert	Yes	
Perkins Brook	Men02T	43° 10' 57.8388" 71° 4' 25.7700"	Major inflow previously	Yes	
Howe Brook	Men05T	43° 10' 57.6660" 71° 4' 10.2648"	Site above McDaniel Shore Road	Yes	
Howe Brook II	Men06T	43° 10' 58.0764" 71° 4' 13.9656"	Runs into Men05T below road	Yes	
McDaniel Brook	Men03T	43° 10' 52.8744" 71° 3' 49.6980"	2nd major inflow previously; Need to sample above Men04T inflow	Yes	
Golden Brook	Men04T	43° 10' 55.9416" 71° 3' 51.5880"	From culvert below road	Yes	
Powerline Brook	Men07T	43° 10' 15.3768" 71° 3' 25.9236"	Very close to Men17T	Yes	
Seasonal Brook	Men17T	43° 10' 15.3300" 71° 3' 25.8264"	See above	Yes	
Little Powerline Brk.	Men08T	43° 10' 12.6480" 71° 3' 29.3652"	Wetland drainage	Yes	
Little Bridge Brook	Men10T	43° 9' 56.9736" 71° 3' 42.8868"	At UNH property: steep gradient	Yes	
Bridge Brook	Men09T	43° 9' 57.3732" 71° 3' 43.5636"	At UNH property	Yes	
Outlet	Men11OT	TBD	Below dam at stream channel	Yes	
Dam Spillway	Men12OT	TBD	Will solicit recommendations from NH DES Dam Bureau	Yes	

8.2.2. Choice Of In-Lake Sampling Stations

Two in-lake sampling locations have been selected on Mendums Pond that have been included in past sampling efforts undertaken by the CFB and the NH Lakes Lay Monitoring Program documented in the annual volunteer monitoring reports provided since 1988 (LLMP 1988-2006). The two sampling sites are positioned at the two deepest points in Mendums Pond that effectively represent the two independent basins of the Pond. During the period of thermal stratification, these two basins can effectively function as two “independent lakes” where the chemical, physical and biological characteristics can potentially exhibit appreciable variation. In lake nutrient conditions are important to track for correlating the lake watershed loading impacts The monitoring of the two deep sampling locations also will provide insight into the differences, and similarities between the two sites that could be important when considering future remedial actions for the pond and the susceptibility of the two Mendums Pond basins to water quality degradation.

8.2.3. Precipitation/Evaporation Data

A Global Water RG600 automated recording rain gauge will be deployed in the Mendums Pond watershed adjacent to the pond to obtain ambient rainfall measurements that will be used to develop the Mendums Pond water/nutrient budget. Supplemental precipitation and climatological data will be obtained from National Oceanic and Administration National Climate Data Center sampling stations located in the town of Durham and the City of Concord for comparative purposes and to ensure daily data, necessary for this study, are available. Supplemental data will also be obtained from the Massabesic Lake climatological sampling station to provide estimates for evaporation rates that are not recorded at either the Durham or the Concord climatological sampling stations.

8.2.4. Choice of Seepage Meter Deployment Locations

Selected sites will follow those previously used by NHDES (Appendix F) whenever possible to afford the best temporal comparison. Those sites provided excellent representation of areas with varying bottom type and areas that had varying levels of shoreline development.

8.3. Rationales for Parameters Measured and Samples Taken

Table 10 summarizes the various rationales for including the different measurements.

Table 10. Sampling Parameters and Rationale

Sampling Parameters	Rationale
Total Phosphorus	Phosphorus (P) tends to be the limiting nutrient in lakes. Total phosphorus is the sum of phosphorus in all its forms and can be used to determine a ponds’ trophic state. Phosphorus is also considered the limiting nutrient in freshwater systems and quantifying the phosphorus load is of paramount importance in lake management.
Precipitation	Precipitation will influence the amount of overland runoff, groundwater recharge and can be correlated to nutrient and sediment loading episodes. Precipitation quantities will be needed to complete the Mendums Pond water/nutrient budget.

Sampling Parameters	Rationale
Turbidity	Turbidity reflects the amount of particulate matter and will provide some insight into whether the "total phosphorus" is entering the lake in a particulate or dissolved form. Turbidity will also serve as an indicator of areas within the watershed where sediment erosion is of the greatest concern.
Temperature	Temperature is correlated to what types of aquatic organisms can survive in the lake and the streams. Temperature variations can also reflect differences in the amount of riparian cover in the Mendums Pond subwatersheds.
Specific Conductivity	Specific Conductivity will provide an insight into local geological variations among the sampling stations, as well as, provide insight into regions where road salt runoff, nutrient runoff, etc might be impacting the water quality.
Total Alkalinity	Alkalinity is generally low in New Hampshire Lakes and provides insight into the susceptibility of Mendums Pond to acid precipitation.
pH	An indicator of acid loading, pH also influences nutrient availability from the sediments and impacts the fitness and distribution of aquatic organisms.
Dissolved Oxygen	Dissolved oxygen concentrations are essentially for a healthy fishery and are also associated with the eutrophication process. Anoxic conditions are commonly associated with internal nutrient loading in many New Hampshire lakes.
Oxidation Reduction Potential (ORP)	ORP profiles in Mendums Pond will be used to determine whether the chemical conditions are conducive to internal nutrient loading and if so, how the in-lake chemistry may vary from April to November.
Secchi Disk Transparency	Water transparency integrates the impacts of sediments, algal cells, true color and detrital debris that is flushed into the lake. The Secchi Disk transparency measurements will provide water transparency data that can be compared to data collected historically.
Chlorophyll *a*	Chlorophyll a serves as a good estimator of algal biomass. The collection and analysis of chlorophyll samples is relatively simple and will provide insight into the trophic condition of Mendums Pond.
True Color	True color can have a significant impact on the water clarity, particularly in watersheds such as the Mendums Pond watershed where considerable wetland drainage exists. True color measurements provide insight into the causes of water transparency variations as well as insight into the seasonal variations in the amount of wetland drainage into Mendums Pond.
Zooplankton	Zooplankton are near the base of the food chain and are important from the standpoint of assessing the ecological integrity of a system. Zooplankton also act as a biological control of phytoplankton and knowledge of their composition is an element of lake management

Sampling Parameters	Rationale
Phytoplankton	Phytoplankton abundance and diversity is correlated to the nutrient load and other physical and chemical variable. Knowledge of the phytoplankton population will provide additional insight into the condition of Mendums Pond.
Underwater irradiance	Light measurements will help determine whether there are significant physical and biological variations vertically throughout the water column.
Total Suspended Solids (accessory parameter)	Total suspended solids provide a quantitative assessment of the particulate load to the lake and would help assess whether sediment erosion is a significant problem within any of the Mendums Pond subwatersheds.
Total Nitrogen (accessory parameter)	While phosphorus (P) tends to be the limiting nutrient of lakes, nitrogen is also very important and can have implications in what algal species dominate in a lentic system.
Anions/Cations (accessory parameter)	For the seepage study; may contribute to the understanding of influence of geology and shoreline development on groundwater nutrient levels.

9.0 SAMPLING METHOD PROCEDURE REQUIREMENTS

9.1. Sampling Procedures

The requirements for the type of container used to collect water samples are based on the chemical analysis conducted, and the use of preservative (Table 11). See Table 12 for method description.

Table 11. Sampling Method Requirements for Water Samples

Parameter	Sample Matrix/ Collection Method	Collected Sample Volume	Sample Holding Container[1]	Preservative	Maximum Holding Time
Alkalinity pH Carbon Dioxide Turbidity	Water; grab	250 ml	250 ml Opaque HDPE[1] plastic	On ice	<8 hours
Dissolved Oxygen	Water; grab	300 ml	300 ml Wheaton glass BOD bottle	On ice w/ manganous sulfate, alkali-iodide-azide and H_2SO_4	<8 hours
Chlorophyll *a* True color Phytoplankton	Water; grab & composite	2 liter	2 l Opaque HDPE plastic	On ice	< 8 hours[2]
Zooplankton	Vertical net haul	400 ml	500 ml wide mouth plastic HDPE	Formalin sucrose solution	< 6 months
Total Phosphorus Total Nitrogen	Water: grab & composite	490 ml	Individual 250 ml Plastic HDPE for each	Acidified w/ H_2SO_4 to pH <2 / iced in field / frozen within 8 hours of sample collection	<90 days[3]
Ortho-Phosphate Total Dissolved Nitrogen Nitrate Nitrogen Ammonium Nitrogen Cations/Anions: Silicate, Sodium, Potassium, , Sulfate Magnesium, Calcium, Chloride	Water; grab & composite (*NOTE: will only be collected if supplemental funding is secured; will be analyzed through UNH WQA lab*)	55 ml	60 ml Plastic HDPE	Filtered / iced / frozen within 8 hours of sample collection	Indefinite[4]

(Based on EPA NE Worksheet 12b)

[1] HDPE-High Density Polyethylene.

[2] Chlorophyll and color samples are filtered within eight hours of sample collection and the color samples are then refrigerated with a seven day holding time and the chlorophyll a samples are frozen with a 28 day holding time. The phytoplankton samples are collected in 40 ml Histoplex containers within 8 hours of collection, preserved with Lugol's solution, refrigerated and quantified microscopically within six months of preservation.

[3] Expected target holding times are indicated for nutrient analysis; however documentation in the literature on unacidified samples (Canfield et al 2002) and UNH CFB analyses on acid preserved samples have shown samples remain stable for over 150 days.

[4] The UNH WQA lab will usually process these samples within 3 months of receipt. However, their documentation and references state "indefinite" as a maximum holding time and is consistent with maximum holding times reported in previously EPA NE approved QAPPs for this lab with similar data quality objectives to this study.

The standard operating procedures for field sampling are provided in Appendices B and C. Appendix D contains the QA Plan for the UNH Water Quality Analysis Laboratory. This document describes the general SOPs for the laboratory. This QA plan has been included with other QAPPs that have been approved by EPA New England for projects with similar data quality objectives.

9.2. Sampling SOP Modifications

It is not expected that any modification of sampling will occur. However, corrective action in the field may be needed if the sampling strategy needs to be modified (i.e., sampling additional sample locations other than those specified in the QAPP, not enough water or sediment sample to meet original requirements, etc.), or when sampling procedures and/or field analytical procedures require modification, due to equipment failure or unexpected conditions. In general, the field team may identify the need for corrective action on-site. The field staff, in consultation with the UNH Project Manager (or if absent, the senior field technician), will evaluate and suggest a corrective action. The field team will implement the corrective action. Any modifications/corrective actions will be noted on the field data forms. The UNH QA Officer will be notified as soon as possible and will provide the field team with any additional actions required to maintain quality assurance and control with respect to corrective actions. It will be the responsibility of the UNH Project Manager to ensure the corrective action has been implemented correctly and reported to the NHDES Project Manager and QA Officer, and the EPA New England QA Officer. If any of the aforementioned QA Officers have additional actions recommended to maintain quality assurance and control they will be implemented retroactively, if possible, and for any sampling events after the event that triggered the corrective action.

9.3. Cleaning and Decontamination of Equipment / Sample Containers

Prior to use, all samplers and tools will be vigorously cleaned with a no-phosphorus detergent (i.e., Alconox) and rinsed generously with distilled water. Between deployments and between sites the samplers will be scrubbed and rinsed three times with distilled water. New, pre-cleaned tubing will be used for interstitial pore water collection at each site for each deployment. All sample containers for nutrients will be washed in an acid bath (10% HCL) and triple rinsed with deionized (Millipore Milli Q System) distilled water (DDI water). All other sample containers will be washed in Alconox and triple rinsed in DDI water. As the transfer of potentially invasive species is of concern all biological materials will be washed off of equipment, gear, clothing and carrying cases while on-site. No decontamination by-products of any consequence are expected to be generated in the field. SOPs for cleaning and decontamination can be found in Appendices A, B and D.

9.4. Field Equipment Calibration

Field Equipment will be calibrated in accordance with the manufacturer calibration directions:

The Hanna Instruments model HI 9025 pH meter with a Beckman Star® low ionic strength combination electrode shall be calibrated on the day of measurement using the built in calibration process and pH 7 and pH 4 buffers according to the manufacturers directions. After calibration the probe will be rinsed three times with DDI water and placed in a beaker of lake surface water for at least 5 minutes to condition the probe for measurement. Two DDI water rinses and blotting with a KimWipe ® tissue will be done between sample readings. Following all sample analyses for a batch, a new sample of 7.0 pH buffer will be measured and the results will be recorded on the field sheet.

The LaMotte 2020 Turbidimeter will be calibrated immediately prior to use in accordance with the suggested manufacturer's calibration procedures using calibration solutions of 0.1 and 20 NTU. The glass turbidity cells shall be rinsed three times with DDI water between samples and the exterior of the cell shall be wiped with a Kimwipe by placing circling the cell with the Kimwipe and, while holding the Kimwipe against the glass vial, the cell will be rotated by twisting the "cap" to produce a minimum of 10 cycles. Past CFB analysis has indicated that this vial wiping approach is the most efficient at removing smudges from the glass vial that might otherwise interfere with the optics. Following all sample analyses for a batch, a new sample of 20 NTU buffer will be measured and the results will be recorded on the laboratory datasheet.

The YSI Model 30 Conductivity meter will be calibrated immediately prior to use in accordance with the manufacturer's suggested calibration procedures using a 1000 μS/cm specific conductivity standard. The sampling probe will be rinsed with DDI water by dipping the probe into a DDI water filled beaker three successive times followed by a DDI water rinse that is applied using a Nalgene squirt bottle. The "rinse" beaker will be rinsed and replenished with uncontaminated DDI water between samples. Prior to taking the first measurements, a 100 μS/cm specific conductivity standard will be analyzed and the results recorded to ensure the meter is holding calibration in the typical range of specific conductivity readings. The 100 μS/cm standard will be poured into a clean beaker and the conductivity probe shall be rinsed with the 100 μS/cm standard prior to submersion into the beaker. The results will be recorded on the laboratory datasheet. The temperature probe will be tested against a NIST traceable thermometer prior to the first use of the year and on a quarterly basis thereafter. The YSI Model 30 temperature probe and the NIST thermometer will be submersed into a beaker filled with tap water at the ambient room temperature (between 15 and 20^{o}C) and that contains a magnetic stirring bar. The beaker will be placed on a stirring plate, set on a low setting, and allowed to circulate to a homogeneous temperature for five minutes. Following the equilibration period, the temperature readings shall be recorded from both the Conductivity meter and the NIST certified thermometer. A temperature difference of <= 0.1^{o}C between the two instruments shall be deemed acceptable (i.e. they fall within the manufacturer specifications) and no reconciliation action shall be taken. Should the temperature differ by greater than 0.1^{o}C the YSI Model 30 shall be sent in for servicing through the manufacturer, Yellow Spring Instruments, or through the University of New Hampshire Instrumentation Center.

The YSI 6600 Sonde conductivity (100uS/cm), pH (7 and 5 buffer), and ORP (Zobel solution) probes will be calibrated prior to the sample trip. Depth, Chlorophyll fluorescence (blank) and dissolved oxygen (saturation) probes are calibrated directly before each deployment on-site. All calibrations are done according to the YSI 6600 User's Manual. Upon return to the lab standard solutions are re-read for conductivity, pH and ORP to check for drift. Readings are recorded in the instrument log and on the digital dataset contained in the logger.

No calibration is require for the Li-cor 1400 data logger, underwater quantum sensor or deck cell as the sensors are NIST certified and we use this instrument to calculate relative light extinction with depth. Equipment performance can be ascertained by performing the regression analyses as described in the SOP for this instrument (Appendix C).

The YSI SonTek ADV velocity meter only requires occasional calibration when indicated by its internal diagnostics. Calibration, when necessary, is performed as directed in the user's manual.

9.5. Field Equipment Maintenance, Testing and Inspection Requirements

Equipment will be inspected prior to and following each use. The Hanna Instruments model HI 9025 pH meter will be inspected for any visible damage and for battery condition. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the pH electrode will be inspected for dirt and scratches. The cables and connectors of the pH and temperature probes will also be inspected for damage. More filling solution (1 M AgCl) will be added to the pH probe if necessary. During storage and transport the pH probe will be protected by an attached storage bottle holding the appropriate storage solution.

The LaMotte 2020 Turbidimeter will be inspected for any visible damage and for battery conditions. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the Turbidity sample vials will be inspected for dirt and scratches. Damaged vials shall be discarded and replaced. The meter and vials will be protected by placing the instrument and accessories into the manufactures storage case between uses.

The YSI Model 30 Temperature/Conductivity meter will be inspected for visible damage and for battery conditions. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the cable will be inspected for kinks and damage and the cable will be inspected to ensure the depth markings are clearly visible. The meter and cable will be stored in a designated storage container between uses.

The Global Water RG600 tipping bucket rain gauge will be subjected to a calibration check immediately before deployment and on a quarterly basis thereafter to ensure the unit is properly calibrated. The calibration procedure will be followed as specified in the Global Water RG600 Operation Manual. Prior to any deployment, the batteries will be replaced with new batteries whose expiration date will not be exceeded while the rain gauge instrument is deployed.

The YSI 6600 Sonde and probes will be inspected for visible damage and the battery conditions shall be assessed in both the YSI 6600 Sonde and the YSI 650 data logger. Prior to calibration and before storage, the cable will be inspected for kinks and damage. All probes shall be inspected to ensure that they are securely anchored in the Sonde housing before use. The optical probes, turbidity and chlorophyll shall be inspected to ensure the optical surfaces are clear and that a sponge (wiper) is affixed to each probe. The pH probe will be inspected for scratches while the dissolved oxygen probe will be inspected to ensure no air bubbles have formed in the cell and to ensure that the membrane does not contain any folds or creases. All probes shall be inspected to ensure they are clean and to ensure that no growth has fouled any of the probe . Should either the YSI 6600 Sonde or the 650 data logger appear to have malfunctioned the instruments will be serviced by the Yellow Springs instruments service center. Likewise defective probes, if deemed cost effective, will be serviced through the YSI service center. Alternatively, replacement probes will be purchased and mounted on the YSI 6600 Sonde. Any such discrepancy or corrective action shall be recorded in the equipment maintenance log book.

The Li-cor 1400 data logger and probes will be inspected for visible damage and the battery conditions shall be assessed. Prior to use, both the deck cell and the submersible cell cables will be inspected for kinks and damage while both optical sensors shall be inspected to ensure that there is no fouling agent on either sensor. The submersible cell cable depth markings will be inspected and calibrated and any repairs will be recorded in the equipment maintenance log book.

The YSI Son-Tek ADV velocity meter and probe will be inspected for visible damage and the battery conditions shall be assessed. Prior to use, the probe cable will be inspected for kinks and damage and the flow sensor shall be inspected to ensure that there is no fouling agent on either sensor. as directed in the user's manual. The top setting wading rod will also be inspected for damage and the mounting screw will be tightened when necessary. Any repairs will be recorded in the equipment maintenance log book.

Prior to sampling and again before storage, the water quality sampling equipment, that includes the plankton net, the Van Dorn and the integrated samplers, the IPWS and the seepage meter components will be inspected for damage, integrity, cleanliness, blockages as well as full operation of moving parts and closing mechanisms. Lines and tubing will be inspected for damage, perforation and kinks. All depth markings on cables and lines will be checked for accuracy. Any discrepancies and repairs will be recorded in the field logbook and copied to the equipment maintenance log book upon return to the lab.

9.6. Inspection and Acceptance Requirements for Supplies / Sample Containers

Sample bottles (characteristics listed in Table 11) will be purchased through Fisher Scientific or VWR International. Prior to sampling, the project manager, lab manager or a designated field team member will inspect the bottles for breaks or cracks and replace them when appropriate. Sampling teams will take two extra sets of bottles in case of cracks, breaks, loss or contamination discovered in the field. DDI water that will be used for field blanks will be placed in a 3 L opaque HDPE bottle and transported with other sample bottles to the field. For all containers, integrity, cleanness and seal will be assessed in the field prior to use.

10.0 SAMPLE HANDLING, TRACKING AND CUSTODY REQUIREMENTS

10.1. Sample Collection Documentation

A combination of field log books, field data sheets and a consistent labeling protocol will help ensure sample authenticity, data integrity and project completion goals

10.1.1. Field Notes

The sampling team will complete field data log books and forms on-site at the time of sampling and/or when measurements are made. Field log books will provide the means of recording the data collecting activities performed during the investigation. As such, entries will be described in as much detail as possible so that persons going to the site could reconstruct a particular situation without reliance on memory.

The log books will contain the following information:

- Date / Time Arrived and Time Left
- Sampling Site ID (w/ Location and Coordinates)
- Full Names of Field Team Members
- Additional Persons Present
- Weather Conditions Throughout Visit
- General Observations
- Transportation Details
- Equipment Employed and Calibrations
- Measurements Made
- Photos Taken

In addition to the field logbooks, field data sheets will be used. One sheet will be used at each sampling location to ensure that all information specific to a particular site is archived on one standardized datasheet. There will be four standard datasheets employed in this study (see appendix E):

- CFB Lake Sampling Datasheet
- CFB Stream Sampling Datasheet
- Volunteer Stream Sampling Datasheet
- CFB Groundwater Study Datasheet

Chain of custody forms will also be initiated in the field to document sample handling, preservation, transport and condition upon arrival to the lab.

All entries will be made in waterproof indelible ink. As data forms are considered an important part of the QA process no erasures or obliterations will be made. Instead, if an incorrect entry is made, the information will be crossed out with a single strike mark that is initialed and dated by the sampler. Field personnel will sign and date all forms when sampling is completed at the site.

10.1.2. Field Documentation Management System

All datasheets (described above) will be submitted upon return from the field or upon delivery of water quality and sediment samples to the UNH Laboratory Manager or UNH Project Manager. The datasheets will be compiled in three ring binders housed in the CFB laboratory and maintained by the Laboratory Manager. All requests for data, datasheets and logs for project personnel will be facilitated through photocopies of the original materials.

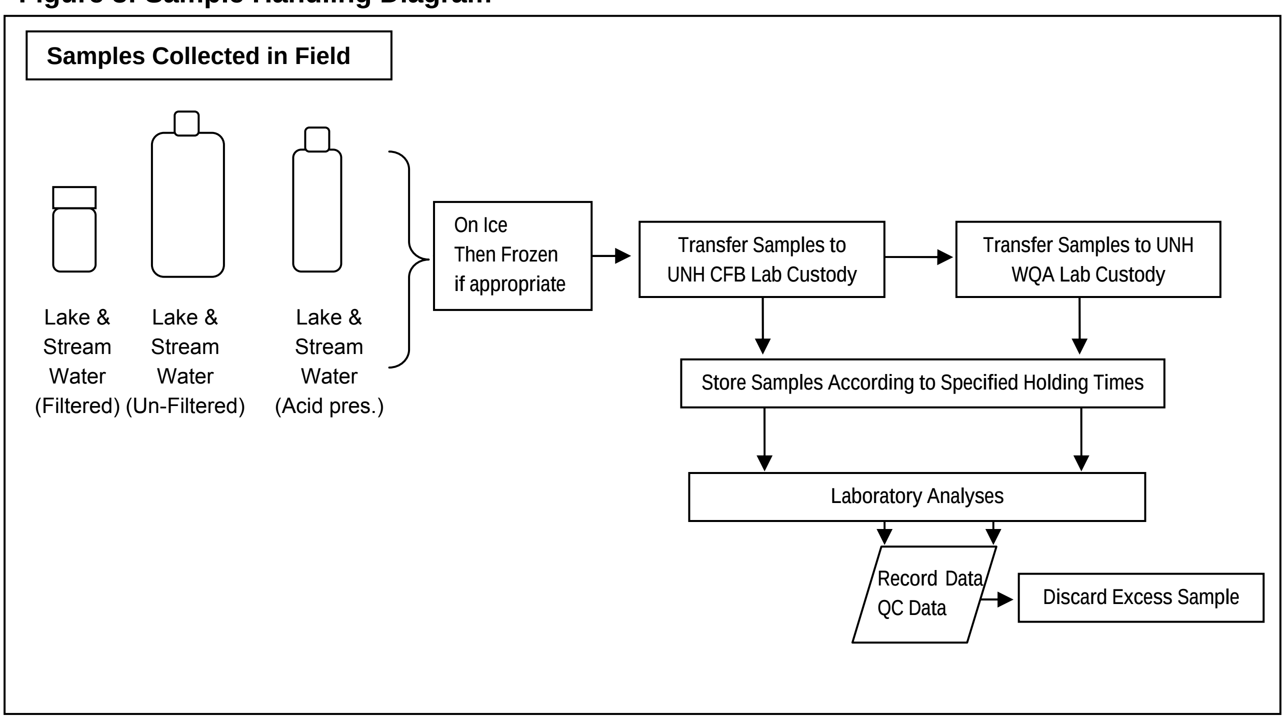
10.2. Sample Handling and Tracking System

All sample bottles will be labeled in the field (Figure 2) and entered onto a chain-of-custody (COC) form before leaving the site. All samples taken will be logged into the field logbook before delivery and also in the sampling logbook kept in the UNH Center for Freshwater Biology lab (see below) upon arrival. All samples will be iced immediately after collection in the field and transported to the CFB lab where they will either be frozen in the lab freezer or refrigerated until analyzed, in accordance with SOPs, after log and database entry. Samples filtered and placed on ice in the field for dissolved nutrient and ion analysis will be frozen prior to transport to the WQA lab. Site names and ID numbers will be standardized by the UNH Project Manager (see Table 9 for Tributary site names and IDs).

Figure 2: Sample Label.

UNH Mendums Pond Watershed Assessment Project
Date:__/__/__ Collection Time__:__hrs
Lake____Stream____Groundwater____ Matrix: Water
Site Name/Number__________________ Depth_______
Acid Preserved Y N / Filtered Y N / Frozen Y N
Tests Requested:_______________________________
Sample Team:__________________________________

Figure 3: Sample Handling Diagram



10.3. Sample Custody

All samples for analysis will be directed to the Laboratory Manager at the UNH CFB Analytical lab. Water sample delivery will be documented on the appropriate chain of custody form as well as into the laboratory sample MS Access database and sample logbook. The CFB Laboratory Manager will inventory samples and review each field data form and contact the Project Manager within 72 hours if unresolvable problems occur or if samples are missing. The sampling logbook will be maintained by the CFB Laboratory Manager to document the custody of the water samples from the field to the analytical laboratory and will include the following:

1. Lake or stream name, station number, sample identification and GPS location,
2. Date and time the sample was collected,
3. Sample type: Grab, Composite or Seepage
4. Sample matrix: Water
5. Preservation technique used in each container,
6. The analysis requested,
7. Sampler name if signature found on COC form,
8. Date and time the samples were delivered to the lab,
9. Condition of sample (i.e. cold, frozen, broken, leaking, etc).
10. Storage or transfer location of sample with date and time.

The chain of custody for water samples is as follows: In the field, samples are the responsibility of, and stay with the sampling team. Once all of the samples have been collected they will be transported to the UNH Center for Freshwater Biology Laboratory for analysis by a field team member. The CFB laboratory manager will record the date and time of arrival, will note the sample condition in the log, will update the chain of custody form and then freeze, refrigerate and/or arrange for transport to the proper lab. Samples for dissolved nutrients and selected ion analysis will be kept frozen and in the dark during building to building transport from the CFB lab to the WQA lab. Photocopies of the original chain of custody forms will be made and included with any samples delivered to another lab for completion. These forms will then be returned when sample analytical results are reported and filed with the original forms.

A sample project Chain of Custody Form can be found in Appendix E

Samples will be analyzed within their respective allowable holding times as listed in Table 11. Sample handling and custody procedures for the UNH Water Quality Analysis Lab are described in Section III of Appendix D.

11.0 ANALYTICAL METHODS REQUIREMENTS (FIELD AND FIXED LABORATORY)

11.1. Analytical Methods and SOPs

The analytical measurements that will be made are all based on existing standard methods (Table 12). The standard operating procedures (SOP) for measurements made in the field are included in Appendix B. The SOPs for the nutrient and organic matter analyses done by the CFB lab are in Appendix A and the SOPs for analyses done by the UNH WQA Lab are listed in Appendix D. Maximum sample holding times are listed in Table 11. Footnotes at the end of the table below indicate the requested turn-around times for analyses.

Table 12. Analytical Methods

Analyte	Matrix	SOP Appendix	Analytical Method Description And Method Citation
Field Measurements			
Temperature	Stream Water	B.6	YSI Model 30 Temperature/Conductivity meter. Instrument Manual; Standard Methods 2550B
Conductivity	Stream Water	B.6	YSI Model 30 Temperature/Conductivity meter. Instrument Manual; Standard Methods 2510B
Stream Velocity	Stream Water	B.7	YSI SonTek FlowTracker Handheld ADV Instrument Manual
Depth	Lake Water	B.8	YSI 6600 Sonde, Instrument Manual
Temperature	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6560 Temperature/Conductivity Probe. Instrument Manual; Standard Methods 2550B
Dissolved Oxygen	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6562 Dissolved Oxygen Probe. Instrument Manual; Standard Methods 4500-O G.
Conductivity	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6560 Temperature/Conductivity Probe. Instrument Manual; Standard Methods 2510B
pH	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6565 Combination pH/ORP Probe. Instrument Manual; Standard Methods 4500-H^+ B.
Oxidation/Reduction Potential	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6565 Combination pH/ORP Probe. Instrument Manual; Standard Methods 2580 B.
Turbidity	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6136 Turbidity Probe. Instrument Manual; USEPA 180.1
Chlorophyll *a*	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6025 Chlorophyll Probe. Instrument Manual;
Underwater Irradiance	Lake Water	C	Li-Cor 1400 Data Logger / LI-192 Underwater Quantum Sensor / LI-191 Deck Quantum Sensor Instrument Manuals;
Lab Analysis (lake/stream water/groundwater)			
Total Alkalinity[1]	Lake & Stream Waters	B.2	Low Alkalinity Titration to pH 4.5 ; Standard Methods 2320 B.
Total Phosphorus[2]	Lake Stream and Groundwater	A.3	Acid Digestion; Standard Methods 4500-P.E.
Dissolved Oxygen[1]	Lake Water	A.10	Winkler Titration via Std. Meth. 4500-O2 B.C.
Carbon Dioxide[1]		A.09	Titration via Std. Meth. 4500 CO2-C.
pH[1]	Stream Water	B.1	Hanna Model HI 9025 Meter / low ionic strength probe. Instrument Manual; Standard Methods 4500H^+
Turbidity[1]		B.5	LaMotte Model 2020 Turbidimeter. Instrument Manual; USEPA 180.1

Analyte	Matrix	SOP Appendix	Analytical Method Description And Method Citation
Total Nitrogen*[2]	Lake, Stream and Ground Water (supplemental parameters if funding is provided)	A.5	Basic Persulphate Digestion; Derivative Spectroscopy. Standard Methods 4500NO_3.C (proposed; see SOP)
Total Dissolved Nitrogen*[3]		D	High Temp. Catalytic Oxidation with Chemiluminescent N Detection (Merriam et al, 1996)
Ortho-Phosphate*[3]		D	Automated Ascorbic Acid; USUSEPA 365
Nitrate Nitrogen*[3]		D D	Automated Cd/Cu Reduction; USEPA 353.2
Ammonium Nitrogen*[3]		D	Automated Phenate; USEPA 350.1
Sodium*[3]		D	Cations via ion chromatography and conductivity USEPA 300.1
Potassium*[3]		D	
Magnesium*[3]		D	
Calcium*[3]		D	
Chloride*[3]		D	Anions via ion chromatography w/ suppressed conductivity. USEPA 300.1
Sulfate*[3]		D	
Silicate*[3]		D	

(based on EPA NE Worksheet 17 and 20)

*- Optional or parameters pending supplemental funding source
[1] –As soon as samples are in lab and within 8 hours of collection.
[2] – Within 20 days of collection.
[3] – Within 3 months of collection

11.2. Analytical Method/SOP Modifications

A weaker concentration of H_2SO_4 acid titrant (.002N vs .02N) than the standard method will be used to increase the sensitivity of the test for the low alkalinity waters expected to be encountered at Mendums Pond Modifications to the other standard procedures listed above are not expected to be necessary. However, if Quality Assurance goals are not being met or if sample concentrations are not within typical range and minor corrective action or SOP modifications are warranted, the Laboratory Manager will be responsible to initiate corrective actions and inform the Project Manager. It will be the responsibility of the UNH Project Manager to ensure the corrective action has been implemented correctly and reported to the NH DES Project Manager and QA Officer, and the EPA-NE QA Officer. Any major analytical method SOP modifications will be implemented only after consultation with NH DES and EPA-NE Quality Assurance Officers and will require a new revision of the project QAPP to be approved. All major and minor corrective actions will be documented and reported.

11.3. Analytical Instrument Calibration

Field instrument requirements for the pH meter, the YSI Model 30 temperature/conductivity meter, the Lamotte 2020 Turbidimeter, Li-cor 1400 photometer instrumentation, the YSI Son-tek ADV flow meter and the YSI 6600 Sonde and analytical probes are discussed in section 9-3. Spectrophotometers will be used in the analysis of phosphorus (Thermo Electron Spectronic model

1001+) and nitrogen (Varian Instruments model Cary 50 Scanning UV/Vis Spectrophotometer) at the UNH CFB Laboratory. Before each use the spectrophotometer is inspected and the light path optics of the sample cuvette is cleaned with lens paper. At the beginning of each analytical run, a series of predetermined standards are used to generate a multi-point initial calibration curve. During use, calibration blanks are re-run to check for instrument drift after every ten sample readings and at the end of each sample run. If significant drift occurs (a difference greater than 0.001 Absorbance units), the instrument is recalibrated, blanked and the samples are re-run. The analytical balance (Denver Instruments Model A220) is tested for accuracy on a monthly basis using NIST traceable standard weights and recalibrated when needed. All calibrations are logged and any problematic occurrences are noted in the CFB instrument logbook kept in the Laboratory Managers office. Equipment calibration procedures for the WQA lab are listed in Section V of Appendix D. Special care will be taken in the use and disposal of the Zobell's solution used to calibrate the Redox probe on the YSI 6600 Sonde. All procedures will be consistent with the UNH Office of Environmental Health and Safety Hazardous Waste Disposal Manual.

11.4. Analytical Instrument / Equipment Maintenance, Testing and Inspection Requirements

Field instrument requirements for the pH meter, the YSI Model 30 temperature/conductivity meter, the Lamotte 2020 Turbidimeter, Li-cor 1400 photometer instrumentation, the Global Water RG600 rain gauge, the YSI Son-tek ADV, and the YSI 6600 Sonde and analytical probes are discussed in Section 9.4. Cleaning and decontamination procedures are discussed in Section 9.3. The spectrophotometers at the UNH CFB Laboratory will be inspected (including internal diagnostic checks) and maintained according to the manufacturer specifications. The spectrophotometers will undergo a standard inspection/cleaning before the beginning of the sampling season (each spring) through the University of New Hampshire Instrumentation Center housed in the University of New Hampshire Chemistry Department. The analytical balance is kept clean and level and is inspected before each use. Full accuracy testing occurs on a monthly basis. All diagnostic and maintenance information will be entered into the CFB instrument log book. Equipment inspections and maintenance schedules for the WQA Laboratory are described in Section IX of Appendix D. No problematic waste disposal issues are expected for maintenance, testing and inspection procedures described here.

11.5. Analytical Inspection and Acceptance Requirements for Supplies

All necessary supplies will be acquired before the start of the study and stock will be inspected and maintained throughout the course of the project by the Laboratory Manager. All stock reagents for the lab and field analyses are bar coded and logged into the UNH Chemical Environmental Management System (UNH CEMS) administered by The UNH Office of Environmental Health and Safety. The UNH CEMS system allows for maintaining chemical inventories and compliance. It also allows for tracking chemical stock and facilitating replacement when nearing the expiration dates. All working solutions are formulated, correctly labeled, stored in the proper container and required conditions, and handled according to the applicable method SOP. Before any field or lab use of reagents occurs they are inspected for container integrity, contamination and expiration date. WQA Lab inspection schedules for consumables are listed in Section V of Appendix D.

12.0 QUALITY CONTROL REQUIREMENTS

Several types of quality control samples will be used to quantify data quality (Table 13). These include both samples collected in the field and those aliquotted in the laboratory (Table 8).

Table 13. Quality Control Samples

Quality Control Sample Type	Definition
Field Blank	A sample of distilled, deionized water that does not contain the measured analytes. The field blank is taken into the field and transferred into sample bottles in the same manner as routine samples (passing through sampling equipment). The field blank facilitates evaluating the entire measurement process from sample collection through lab analysis.
Bottle Blank	A sample of distilled, deionized water that does not contain the measured analytes. This blank is also taken into the field and transferred into sample bottles directly. This blank combined with results from the Field Blank and Laboratory Blank will help determine the source of contamination, if any.
Laboratory Blank	A sample of distilled, deionized water that does not contain measured analytes. The laboratory blank is used to check the cleanliness of the analytical process.
Replicate Samples	A second measurement made with a field instrument or analyzed from the same water or sample container. A replicate measurement will be made for each field measured or analyzed parameter.
Duplicate Samples	Two sub-samples of the same sample are collected in separate containers. The results from duplicate analyses are used to evaluate analytical or measurement precision. The duplicate sample is processed and analyzed in the identical manner as routine samples.
Sample Matrix Spike	A field sample for which a known concentration of the analyte(s) of interest has been added (sometimes called “audit samples”).

Section VII of Appendix D describes the quality control measures that will be used for analyses by the UNH Water Quality Analysis Laboratory.

12.1. Sampling Quality Control

The expected sample load associated with sampling and QC is shown in Table 14. Field duplicate samples will be collected on every sampling event (site visit), which, for example, in the case of tributary phosphorus sampling, will result in at least a minimum of 108 duplicate and blank samples collected throughout the study. This represents ~21% of the sampling load. Field blanks will be collected on each lake sampling event. Bottle Blanks will be collected on all trips and analyzed by the CFB lab. All QC samples will be blind to lab analysts as they will be labeled as they were regular site samples but noted as QC samples in the field log book. In addition, each volunteer monitor will provide at least 2 duplicate samples and one blank per year.

Table 14. Sample Load Breakdown

Analysis	# of Sampling Dates	# of Samples per Site	Total # of locations Sampled (minimum)	Field Duplicates or Replicates (% of samples QC'd)	Field and Bottle Blanks	Total # of Samples to lab (or Total Readings Taken)
Field Measurements (Streams)						
Stream Temperature	18	2	14	1 replicate / site (100%)	NA	Measured in field (504)
Stream Conductivity	18	2	14	1 replicate / site (100%)	NA	Measured in field (504)
Stream Velocity	18	1	14	2 replicate / trip (11%)	NA	Measured in field (transects[1])
Field Samples (Streams)						
Total Phosphorus	36	1	14	2 duplicates / trip (14%)	1 / trip (7%)	576
Turbidity, pH, alkalinity	18	1	14	2 duplicates / trip (14%)	1/ trip (7%)	288
Field Measurements (Lake)						
Depth Temperature Dissolved Oxy. Conductivity pH ORP Turbidity Chlorophyll	5	2	2	2 profiles / site (100%)	NA	Measured in field (profiles[2])
Underwater irradiance	5	2	2	3 profiles / site (200%)	NA	Measured in field (profiles)

[1]- Usually, a minimum of three readings along the transect are taken for stream widths lower than 1 meter. Streams 1 meter to 2 meters in width are measured every 0.25 meters and streams greater than 2 meters are measured every 0.5 meters.

[2]- Profiles at deep sites are measured starting at 0.1 meters depth and the multiparameter sonde is set to record approximately every 0.2 meters. Light profiles are taken at 0.1m, 0.5 m and every 0.5 meters thereafter.

Analysis	# of Sampling Dates	# of Samples per Site	Total # of locations Sampled (minimum)	Field Duplicates or Replicates (% of samples QC'd)	Field and Bottle Blanks	Total # of Samples to lab (or Total Readings Taken)
Field Samples (Lake)						
Total Phosphorus	5	3	2	1 duplicate / trip (17%)	1 / trip (17%)	40
Dissolved Oxy. (Winkler titration)	5	2	2	1 duplicate per trip (25%)	NA	25
Carbon Dioxide and Alkalinity	5	4	2	1 replicate / trip (12.5%)	NA	45
Zooplankton	5	1	2	1 replicate / 2 trips (25%)	NA	11 or 12
Whole water Phytoplankton	5	2	2	1 replicate / 2 trips (12.5%)	NA	22 or 23
Field Measurements and Samples (Groundwater Seepage)						
Seepage Flux	15	1	16	3 replicates / sampling trip (19%)	NA	Measured in field (285)
Pore water Phosphorus	15	1	6	1 replicate / trip (17%)	NA	96

(based on EPA NE Worksheet 22a and 22b)

12.2. Analytical Quality Control

12.2.1. Field Analytical QC

For field measurements using the YSI Temperature/Conductivity meter, the YSI 6600 Sonde, the Lamotte 2020 Turbidimeter, and the Hanna pH meter, duplicate analyses will be performed on 100% of samples. If two readings are off by more than the values shown in Table 8, a third reading will be taken. Triplicate readings will be collected for the Li-cor 1400 irradiance logger to generate standard error data. If the resulting measurement is not within the acceptable range with one of the other samples, the UNH project manager will review the procedures in consultation with other personnel present in the field and decide on the outcome. The measurements may be discarded or one or more may be kept with qualification depending on the findings of the UNH Project Manager (see also Section 18 for validation flag coding and Section 19 for data usability discussion).

12.2.2. Fixed Laboratory QC

Additional QC samples will include lab blanks, lab duplicates, and lab fortified samples (matrix spikes, calibration samples and controls). One laboratory blank will be analyzed at both the beginning and end of each batch of samples analyzed at the CFB laboratory. Laboratory duplicates will compose 100% of the Total Phosphorus, turbidity, pH, alkalinity, dissolved oxygen and carbon dioxide samples that are analyzed. A minimum of 10% of the total phosphorus samples will be spiked. In-lab measured conductivity, pH and turbidity measurements as well as alkalinity and dissolved oxygen titrations will have 100% replicate measurements made. Twenty percent (10%) of the phytoplankton and the zooplankton will be counted twice to ensure the biological data meet DQOs.

Table 15. Use of Quality Control Samples in the Lab for Nutrients

Analysis	Lab Blanks	Lab Duplicate Samples	Lab Fortified Matrix Spike Samples	Calibration Samples	Lab Fortified Blank (QC Control)
UNH CFB Lab					
Total P	**Reagent:** B & E* (>10%) **Instrument:** 1 every 10 spec readings	100% of water	4 per analytical batch (>10%)	5 standards / analytical batch	10%
Total Nitrogen (supplemental if funding is secured)	**Reagent:** B & E* (>10%) **Instrument:** 1 every 10 spec readings	100% of water	4 per analytical batch (>10%)	6 standards / analytical batch	10%

(Based on EPA-NE Worksheet# 24a)

* B & E denote the beginning and end of an analytical run.

13.0 DATA ACQUISITION REQUIREMENTS

It is expected that the majority of the data produced directly by this project will serve to develop the primary findings of the Mendums Pond water/phosphorus budget and the groundwater study. The Total Maximum Daily Load (TMDL) model will be derived from data historically generated through the Department of Environmental Services diagnostic feasibility study of Mendums Pond, NHDES-WSPCD 92-4, whose data were collected in accordance with an EPA approved QAPP. Secondary data historically collected by the NHDES and the UNH CFB will be used to perform comparisons and to support project conclusions. Additional secondary data will be used to perform watershed delineations and to analyze land use variations among the sub watershed. Secondary data and their uses are described in Table 16.

Table 16. Non-Direct Measurements Criteria and Limitations Table

Non-direct measurement (secondary data)	Data source	How data will be used	Limitations on data use
Water Quality Assessment of Mendums Pond	Department of Environmental Services Diagnostic Feasibility Study of Mendums Pond NHDES-WSPCD 92-4	Comparison Purposes; Development of TMDL Report.	Comparable DQO requirements and validated performances to this study; otherwise will notate difference and qualify the data.
Hydrology Data and phosphorus dry deposition estimates	UNH Hydrology Department and Civil Engineering Department	Calculations used in the Mendums Pond water/nutrient budget	Data will be used to validate field collected data and to provide estimates for the Mendums Pond phosphorus budget.
Climatological Data	National Oceanic and Atmospheric Administration National Climatic Data Center: Durham, Concord and Massabesic Lake stations.	Comparison Purposes, lake evaporation data will be needed for the Mendums Pond water/nutrient budget	Precipitation and temperature data will be used to validate field collected data and to provide estimates for the Mendums Pond phosphorus budget.
Water Quality Data: Total Phosphorus, Secchi Transparency, pH, Specific Conductivity. Alkalinity, DO, selected ions.	NH DES, UNH CFB , UNH Lakes Lay Monitoring (historical and recently collected)	Comparison Purposes	Comparable DQO requirements and validated performances to this study; otherwise will notate differences and qualify the data.
Bathymetric maps, topographic maps orthophotos, GIS coverages,	NH DES, NH Fish and Game and UNH GRANIT GIS data coverages.	Subwatershed delineations: land cover assessments: Sample location mapping.	Date of data collection and map creation. GIS metadata standards.

(Based on EPA-NE Worksheet #25)

14.0 DOCUMENTATION, RECORDS AND DATA MANAGEMENT

14.1. Project Documentation and Records

Project documents and records that will be generated by this project are listed in Table 17. The UNH Project Manager has final responsibility for all documentation and records. All documentation and records will be located in the UNH CFB Laboratory Office:

Table 17 Project Documentation and Records.

Sample Collection and Documentation Records	Field Analysis Records	Fixed Laboratory Records	Data Assessment Records
Field log books	Field data sheets	Lab data sheets	Documentation of corrective actions for field sampling, field analysis and fixed laboratory analysis
Field data sheets	Field instrument log book	Instrument log book	
Site Maps		Raw and tabulated results data	
Digital Photographs		Contract lab data results (raw, tabulated and/or digital)	UNH FBG Lab QA/QC documentation and reporting
Chain of Custody Record		Chain of Custody Record	QA/QC section in preliminary reporting

14.2. Field Analysis Data Package Deliverables

Field analytical measurements will be generated on-site. Measurements will be recorded on field data sheets, and these data will be transferred to an electronic spreadsheet (MS Excel) that is a part of the project-specific electronic database system. Entries into the spreadsheet will be compared against the field sheets by a second person as a quality check before it is appended to the project database.

14.3. Fixed Laboratory Data Package Deliverables

The UNH CFB Laboratory will provide the UNH Project Manager with a copy of the sample log book (see Section 10.3), sample custody forms and a computer generated form which includes the laboratory results, the sample number, matrix, collection date and time, log in date and time, analysis completion date, sampling location, who collected the sample and a summary of the QA/QC data. The Water Quality Analysis Laboratory will provide the UNH Project Manager with a data package as described in Section VI of Appendix D.

14.4. Data Reporting Formats

Field and lab entries will be made in indelible ink. No erasures or obliterations will be made. Instead, if an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler or analyst. Field personnel will sign and date all forms when sampling is completed at the site. Laboratory personnel will date and sign all lab analytical data sheets. Field and laboratory data will ultimately be typed into recorded in a password protected computer database (Microsoft Access). All computer datasets will be checked twice for entry or transcription errors before the data are combined into the final project database.

14.5. Data Handling and Management

Data Recording:

Results from field measurements are written onto field datasheets and field logs (see Section 10.1.1 for field notes taken). Results from laboratory analyses at the UNH CFB lab are written onto parameter-specific lab data sheets that are kept in three ring binders in the lab. The results of the analytical measurements are then entered into the computerized (Microsoft Access) laboratory database. The date of completion of laboratory analysis is listed in the sample log book and entered into the computerized database.

Upon receipt of the UNH Water Quality Analytical Lab data deliverables the Lab Manager will update the sample lab book to reflect the date of analyses for those samples.

Data Transformations / Data Reduction:

Data will be analyzed statistically in spreadsheet or statistical analysis programs (see Software below) for ranges, means, medians, standard deviations, standard error, and minimum and maximum values for each sampling event. Calculations used to determine analyte concentrations are listed in the SOPs located in the Appendices. QA data will be analyzed using the formulae listed in Section 7.0 of this QAPP.

Data Transfer / Transmittal:

The UNH CFB lab database is designed to generate lab analysis reports, data summaries and raw data tables. Upon receipt of the Water Quality Analytical Lab data deliverables, and after checking the accompanying QA/QC summary, the CFB Lab Manager will update the sample analytical dataset. All results will be transmitted to the Project Manager for inclusion into the project data base.

The master project database will be maintained by the UNH Project Manager in a MS-Access Database file. All data entry will be done in a separate Excel spreadsheet checked twice and reviewed by the Project Manager before being appended to the master database spreadsheet.

Data Analysis:

The following software will be used in data analysis: Excel spreadsheet software (Microsoft), Sigma Plot analysis and graphing software (Systat Software Inc.). SPSS statistical analysis software (SPSS Inc.) Lakewatch Software (Scientific Software Group). ArcGIS (ESRI) software will be used to create location maps.

Analytical Models:

In addition to any models suggested by NH DES for the development of the phosphorus TMDL, Common lake trophic analysis models authored by Dillon, Rigler, Hutchinson and Reckow (and colleagues) will be run to find the best predictive model for Mendums Pond nutrient loading and chlorophyll response.

Data Assessment:

Field data forms will be reviewed and signed by the sampling team before delivering water samples to the UNH Center for Freshwater Biology Laboratory. Upon arrival at the UNH CFB Laboratory the Lab Manager will review the datasheets for completeness, inventory samples and review chain of custody forms. Any unresolvable errors or omissions regarding samples or field data will be documented and the UNH Project Manager will be notified within 24 hours.

The UNH CFB Lab Manager will review all lab notebooks and computerized data after QC checks have been completed to determine whether the data are acceptable (if the DQOs are not reached the samples will be rerun). After the entry of each sampling event, the data will be assessed using summary statistics, mean, median, standard deviation and coefficient of variation to identify potential outliers and possible measurement errors. Questionable data will be flagged with a code (described in section 18.1) identifying the concern (See also Sections 17 and 18.0 on Data Verification and Validation for additional project data assessment procedures).

14.6. Data Tracking and Control

Data Tracking

As this is a small project with limited scope and a small data set, there is no need for an extensive data tracking system. All data will be analyzed on the University of New Hampshire Durham Campus and all sample transport will be performed by the UNH CFB field technicians. The CFB Lab Manager will assure all samples taken in the field were accounted for and the sample dataset is complete through checks using the sample logbook.

Data Storage, Archival, and Retrieval

In addition to the aforementioned project deliverables, hard copy and digital data summaries and listings will be made available to the Al Wood Road Association, the Towns of Nottingham and Barrington, NHDES and EPA New England in any form(s) requested. However, all data sheets and generated digital data will be in the final custody of the UNH Project Manager, who will make sure that all hard copies and electronic copies are stored in an organized fashion. Hardcopies of all information used and generated for this project will be stored by the project manager for at least 5 years. Electronic copies of the following items: raw data, data summaries, field notes, statistical results, final report will be stored on the computer of the project manager and on a CD backup system indefinitely.

Data Security

Although all data are public information, the project data package will be kept in a limited access area available to the Lab Manager and the Project Manager. All computer data base files are password protected.

15.0 ASSESSMENTS AND RESPONSE ACTIONS

15.1. Planned Assessments

In order to determine that field sampling, field analysis and laboratory activities are occurring as planned, field staff and laboratory personnel shall meet, after the first sampling event, to discuss the methods being employed and to review the quality assurance samples. At this time all concerns regarding the sampling protocols and analysis techniques shall be addressed and any changes deemed necessary shall be made to ensure consistency and quality of subsequent sampling. Any changes in field or lab methods or SOPs will be submitted to NHDES and EPA New England for approval. Assessment frequencies and responsible personnel are shown in Table 18.

Table 18. Project Assessment Summary.

Assessment Type/Activity	Frequency	Responsibility for Assessment	Responsibility for responding to and initiating corrective actions of assessment findings	Responsibility for monitoring effectiveness of corrective actions
Field Sampling Audit	At beginning of study	UNH Project Manager	UNH Project Manager	UNH Project Manager
Field Analytical Audit	At beginning of study	UNH Project Manager	UNH Project Manager	UNH Project Manager
Field Data Verification	After each field trip	UNH Project Manager	UNH Project Manager	UNH Project Manager
UNH CFB Laboratory Analytical Data Verification / Validation	Soon after each analytical batch run	CFB QA Officer	CFB Laboratory Manager	CFB Laboratory Manager
UNH CFB Laboratory Services Audit	Annually	CFB QA Officer	CFB Laboratory Manager	CFB Laboratory Manager
UNH WQA Laboratory Services Audit	Quarterly	WQA Laboratory Manager	WQA Laboratory Manager	WQA Laboratory Manager
QAPP Review	Annually	UNH Project Manager	UNH Project Manager	UNH Project Manager

(Based on EPA-NE Worksheet #27b)

15.2. Assessment Findings and Corrective Action Responses

<u>Field Sampling:</u>

QAPP deviations and project deficiencies determined during the field sampling assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documentation in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity. Field sampling activities will be monitored to determine compliance.

Field Analytical:

QAPP deviations and project deficiencies determined during the field analytical assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documented in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity. Field analytical activities will be monitored to determine compliance.

UNH CFB Laboratory Services Fixed Laboratory:

QAPP deviations and project deficiencies determined during the CFB lab fixed laboratory assessments will be addressed immediately. Duplicates, blanks and critical range tables will be checked with data to determine if sources of error exist. Any deviations in results will be addressed in both written and verbal formats, and future sampling will be monitored to verify that compliance is reached.

UNH WQA Laboratory Fixed Laboratory:

QAPP deviations and project deficiencies determined during the WQA lab fixed laboratory assessments will be addressed immediately. Duplicates, blanks and critical range tables will be checked with data to determine if sources of error exist. Any deviations in results will be addressed in both written and verbal formats, and future sampling will be monitored to verify that compliance is reached.

15.3. Additional QAPP Non-Conformances

Corrective actions will be implemented any time that deviations or errors are noted in field and laboratory work during the project. For example, on completion of an analytical batch run (or soon after) the lab technician will review the results of the run with the laboratory QA officer and any samples not meeting the QAPP requirements will be re-run. Any significant corrective actions (i.e.: change in sampling strategy, change in field or lab methods or SOPs, change in quality control samples) will require the final approval of the UNH Project Manager. Any changes in field or lab methods and SOPs will be reported to NHDES and EPA New England in an annual QAPP review update.

16.0 MANAGEMENT REPORTS

Interim progress reports will be provided to NHDES by the Project Manager using the project reporting form. The final report submitted to NHDES will be written in accordance with the 319 Program Final Report Guidelines. The UNH Project Manager will provide the Project Manager with the appropriate information required for these reports.

As stated in the previous section, reviews of lab and field data will be an ongoing and frequent process. QA data will be included in the Annual QAPP review, any data summaries, project updates and project reports. A QA/QC section will be generated for both the interim and final project reports and will contain:

- an overview of the QA/QC program,
- all data quality assessments, corrective actions and their results,
- attainment or non-attainment of project data quality objectives, completeness of field sampling and lab analyses, and project task achievement summary. All will include the appropriate explanation for attainment or non-attainment,
- verification and validation summaries and
- any limitations on the use of the data related to reconciliation of DQOs.

17.0 VERIFICATION AND VALIDATION REQUIREMENTS

Verification is the review of the sampling and analysis data to see if data required for the completion of the project are available. Validation is the process to assess and document the performance of the field sample collection process and the performance of the lab analytical process. Validation assesses not only compliance with method, procedure, and contract requirements, but also compliance with QAPP-specific requirements. Data of known and documented quality will be provided by these examinations.

Data verification will occur under the supervision of the UNH Laboratory Manager/Quality Assurance Officer through the detailed examination of data sheets and raw data to check for transcription errors, calculations, measurement within calibration range, compound identification and completion. Data validation will consist of an assessment on all field and lab data to check that they meet the data quality objective criteria set forth in this QAPP and specifically listed in Sections 7, 9, 10, 11 and 12. Any discrepancies will be brought to the attention of the UNH Project Manager for action.

18.0 VERIFICATION AND VALIDATION PROCEDURES

This section of the QAPP describes the process that will be followed to verify and validate project data.

18.1. Verification Procedures

<u>Field Data</u>

After each CFB team sampling trip and when volunteer data sheets are submitted, verification reviews for field-based activities are conducted by the UNH Project Manager to ensure data are collected in accordance with this QA Project Plan and documented SOPs. This is achieved by confirming:

- Sampling strategy and sampling methods were followed.
- Field equipment was calibrated and documented on data sheets.
- Data are appropriately documented on the field data sheets.
- There was appropriate reconciliation of documentation errors during calibration and field activities.
- Samples were collected into proper containers, preserved (if necessary) and stored properly.
- The transfer of custody of each water sample is verified correctly on the chain of custody form.
- Any deviations or deficiencies to the above and any resultant corrective actions were documented correctly.

<u>Laboratory Data</u>

Before analytical data results are transmitted from the labs to the UNH Project Manager the respective lab manager will insure complete verification through documentation (memorandum) included with the laboratory data package:

- Samples were received in the proper condition.
- The appropriate methodology was used.
- Instrumentation was functioning properly.
- Instrumentation was calibrated according to QAPP stated schedules.
- Samples were analyzed within the specified holding times.
- All samples delivered were accounted for and analyzed.
- There was appropriate reconciliation of documentation errors during calibration and analysis.
- Any deviations or deficiencies to the above and any resultant corrective actions were documented correctly.

At the conclusion of the project a verification review will be conducted by the Program Manager to ensure consistency between field samples collected, laboratory samples submitted and laboratory data received.

18.2. Validation Procedures

Validation reviews will be ongoing throughout the project following sampling events (staff and volunteer), during and following analytical batch runs, following field and lab data entry, before any data analysis and at the completion of the project prior to final reporting.

Field Data

Validation reviews for field-generated data are conducted at the end of each sampling day, where the UNH Project Manager reviews calibration data and field sampling data (temperature, specific conductivity and in-lake profiling data) to ensure data are within the anticipated limits. The UNH Project Manager screens the data, and discusses any potential outliers with field technicians and/or volunteers . The Program Manager validates the data collected for that particular day by signing the data sheets at the conclusion of each sampling day.

Validation reviews for field-generated data are also conducted throughout the project as data entry activities are conducted and more complete data sets can be examined. The UNH Project Manager screens the data, and discusses any potential inaccuracies with field technicians and/or volunteers before appending data to the project database.

Laboratory Data

Validation reviews for laboratory-generated data are conducted during each batch run by UNH CFB Laboratory technicians under the supervision of the CFB Laboratory QA Manager as previously described. Before analytical data results are transmitted from the labs to the UNH Project Manager the respective lab manager will insure complete validation through documentation (memorandum) included with the laboratory data package. After transmittal of laboratory data to the UNH Project Manager, a validation review is conducted for any potential outliers and blind sample results are checked for meeting acceptance criteria. The UNH Project Manager will contact the respective laboratory QA manager to reconcile any inaccuracies.

Validation will be achieved by confirming:

- All analytes were quantified within the calibration range.
- The analyses met the acceptance criteria for duplicates, spiked samples, control samples, and blanks.
- For any deviations or deficiencies to the above the data were flagged.
- Any resultant corrective actions were documented correctly.

18.2.1. Validation Flagging Codes

Questionable data will be flagged with a code that identifies the nature of the concern. The first digit of the flag code will be: F - field or L - laboratory. Laboratory flags will be coded with a second digit to indicate one of the following:

1. QC blank samples were more than the acceptable value for blanks for that analysis. All samples in the batch will be flagged (generally would have caused a batch re-run at the time of analysis).
2. QC spiked samples were more than the acceptable value for percent recovery. All samples in the batch will be flagged (generally would have caused a batch re-run at the time of analysis).
3. QC reference samples were more than the acceptable recovery value. All samples in the batch will be flagged.
4. The difference between lab duplicate sample results for a collected sample was greater than the acceptable range or the difference between field duplicate samples did not meet the acceptable RPD.
5. The single sample value is more than 2 times the standard deviation of the batch.
6. The sample value is unacceptably high or low (in terms of analytical range) and this datum should not be used.
7. Results of the sample are within all tolerances but there was evidence of possible sample contamination or the sample bottle was not returned intact.

Note that codes 1-3 should trigger a batch re-run, codes 4 and 5 should trigger a sample re-run and code 6 may trigger a sample re-run after a dilution of the sample.

19.0 DATA USABILITY / RECONCILIATION WITH PROJECT QUALITY OBJECTIVES

Upon completion of each sampling event and receipt of water chemistry results from the UNH labs, determinations for precision, accuracy, and completeness will be made by the UNH Project Manager. If necessary, corrective actions will be implemented as described in previous sections. If data quality indicators do not meet the project's specifications, those data will be appropriately flagged. Data may be completely discarded if deemed unusable or not meeting the minimum DQO specifications documented in Sections 7.0 and 12.0 of this report. The cause of failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance, techniques will be assessed and corrected. If the problem is found to be sampling error, sampling methods will be reviewed with all project participants and retraining will occur when necessary. Any revisions in sampling methodology, sample processing, or analytical methods will be submitted to the State and EPA quality assurance officers through a memorandum for approval.

If completeness, representativeness, and comparability goals are not met, then a re-sampling visit will be scheduled if time permits and if it is within project scope and budget. If after all attempts to re-sample and repeat analysis on samples fail and the data set is limited, and questionable data must be used, they will be used for reference only, and they will be footnoted as questionable and not meeting the projects original DQOs. Any decisions made regarding the usability of the data will be left to the UNH Project Manager. However the Project Manager may consult with project personnel, the NH DES Project Coordinator, or with personnel from EPA-NE, if necessary. The UNH Project Manager will ultimately be responsible for determining the acceptability of data and/or for determining if re-sampling is needed. Any limitations on the data used will be detailed in the interim and final project reports, as well as anytime the data set is provided to other data users.

20.0 REFERENCES (FOR QAPP AND APPENDICES)

American Public Health Association.(APHA) 1998. Standard Methods for the Examination of Water and Wastewater, 20th edition. APHA. Washington DC 20005-2605.

Bachmann, R.W. and D.E. Canfield Jr. 1996. Use of an alternative method for monitoring total nitrogen concentrations in Florida Lakes. Hydrobiologia. 323: 1-8.

Canfield, D.E., Jr., C.D. Brown, R.W. Bachmann, and M. V. Hoyer. 2002. Volunteer lake monitoring: Testing the reliability of data collected by the Florida LAKEWATCH program. Lake and Reservoir Management 18(1):1-9

Connor, J., P. McCarthy, M. O'Loan. 1992. Mendums Pond Diagnostic/Feasibility Study. New Hampshire Department of Environmental Services Water Supply and Pollution Control Division. Concord, NH.

Crumpton, W.G. 1992. Nitrate and organic N analyses with second-derivative spectroscopy. Limno. Oceanogr. 37(4): 907-913.

Cooke, G. D.et al. 1993. Restoration and Management of Lake and Reservoirs. Lewis Publishers, Boca Raton. Fl.

Hewlett, J.D. 1982. Principles of Forest Hydrology. University of Georgia Press. Athens, Georgia.

Lakes Lay Monitoring Program (LLMP). 1988-2006 (a series of annual reports of monitoring effort and results). UNH Center for Freshwater Biology (originally Freshwater Biology Group) and UNH Cooperative Extension. Durham, NH.

Merriam, J.L, W.H. McDowell, W.S. Currie, 1996. A high-temperature catalytic oxidation technique for determining total dissolved nitrogen. Soil Science Society of America Journal, 60(4) 1050-1055.

North American Lake Management Society (NALMS). 2001. Managing Lakes and Reservoirs. NALMS, Terrene Institute and EPA Office of Water. EPA 841-B-01-006

U.S. Environmental Protection Agency. 1999. Methods and Guidance for Analysis of Water. Washington DC. EPA-821-C-99-004.